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Page 155, line 6, *read* over in the seed tuber *for* over the seed tuber.

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Page 735, footnote, *read* Rhoads, A. S. *for* Rhodes, A. S.

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PHYTOPATHOLOGY

VOLUME 17 NUMBER 1

JANUARY, 1927

OBSERVATIONS ON FOREST PATHOLOGY IN GREAT BRITAIN AND DENMARK

J. S. Boyce[1]

INTRODUCTION

In the past, Great Britain has paid little attention to growing forests as compared with other European nations. Timber needed was readily and cheaply imported from the Continent and from America, so a "laissez faire" policy was pursued. During the World War, however, the country was in desperate need of timber supplies for use at the front and in the service of supply. Space in ships needed for carrying troops and munitions had to be given over to rough lumber. On the other hand, the Central Powers had been able to maintain themselves effectively from their adequate and well-managed woodlands. At the conclusion of the war Great Britain found it essential to begin extensive reforestation and afforestation. Her woefully inadequate supply of timber, particularly softwoods, was almost completely exhausted. Furthermore, there were large areas of almost waste land in the highlands of Scotland, on which the population was steadily decreasing. Forests on such land would give employment and increase the population.

Unfortunately there is only one conifer of commercial value native to Great Britain, that is, Scotch pine (*Pinus sylvestris* L.), and even its nativ-

[1] During the period May 29 to October 7, 1925, the writer was in Great Britain for the purpose of studying forest tree diseases in general and Douglas fir canker in particular. One short trip was made to Denmark. Throughout the course of this work the writer was accorded every possible assistance. Particular acknowledgement is made to Dr. Malcolm Wilson, Consulting Mycologist to the Forestry Commission, who generously placed his laboratory and his extensive information on tree diseases in Great Britain at the disposal of the writer. Thanks are also due Dr. A. W. Borthwick, Prof. Fraser Story, Dr. H. M. Stevens, Dr. Mark Anderson, and Mr. J. S. L. Waldie of the Forestry Commission for many courtesies, to Dr. Augustine Henry for information on coniferous species, to the Royal Scottish and the Royal English Arboricultural Societies for the privilege of attending their field excursions, and, finally, to Skovrider K. Bramsen in charge of the state forest at Almindingen on the island of Bornholm in Denmark for making possible observations there.

ity is subject to dispute. This species, together wth European larch (*Larix europaea* D.C.), introduced so long ago that many believe it to be native, comprised the bulk of the softwoods grown. These two trees grow slowly, however, and fast-growing trees were needed. Furthermore, they are quite unsuitable to certain sites which cover extensive areas.

While in the past the British, with some exceptions, have been little interested in forestry, they have been enthusiastic arboriculturists, so that specimens of conifers of considerable age from all over the world may be found on the island. These showed that species from that portion of the Pacific Coast of North America north of the California line and west of the summit of the Cascade Mountains were particularly suitable for culture. In fact certain of these species in Britain grow more rapidly, in their youth at least, than they do in their native home. This is probably explainable by climatic differences. In England and Scotland the summers are normally mild and moist—moderate temperatures, abundant showers, and high humidity, while at home during the same period the trees are subjected to relatively high temperatures and long periods of drouth. Mild, wet winters are the rule in both regions.

Of the conifers from the Pacific Coast, Douglas fir (*Pseudotsuga taxifolia* (Lam.) Br.) is most extensively planted, followed by Sitka spruce (*Picea sitchensis* (Bong.) Trautv. and Meyer). Grand fir (*Abies grandis* Lind.) has found considerable favor. Western red cedar (*Thuja plicata* Don.), Port Orford cedar (*Chamaecyparis lawsoniana* Parl.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) are used to some extent. Noble fir (*Abies nobilis* Lind.) is being tried in a small way. Japanese larch (*Larix leptolepis* Murr.) is the only oriental species commonly planted. The continental European species most used are Norway spruce (*Picea excelsa* Lk.) and European larch. Silver fir (*Abies pectinata* D.C.) has rapidly declined in favor, owing to the ravages of the silver fir aphid (*Dreyfusia nuesslini* Börner), presumably imported from the Continent, where it is common on the same host but doing much less damage. Among the pines, Scotch pine is still most fancied, but maritime pine (*Pinus pinaster* Sol.) and Corsican pine (*P. laricio* Poir.), both native to southern Europe, are extensively used. Lodgepole pine (*P. contorta* Loud.) from the northern Rocky Mountains is being experimented with.

But as far as private owners are concerned, the species which is playing a very large part in the planting campaign is Douglas fir, on account of its phenomenal rate of growth. This tree, first introduced into England in 1827 (9, p. 35), almost 100 years ago, was not planted commercially until 1860 and then not in an appreciable amount until the first years of the present century. Extensive planting followed the war.

Douglas fir is also one of the most valuable species in the United States. At present it comprises about one-fourth of our remaining merchantable timber, and its continued existence, owing to its ease of reproduction, its rapidity of growth and its simplicity of management, is of paramount importance to the future softwood supply of this country and to the economic well-being of the Pacific Northwest.

BRITISH NAMES FOR AMERICAN CONIFERS

In the United States only one species of Douglas fir, *Pseudotsuga taxifolia* (Lam.) Britt., is recognized throughout the West. In Great Britain and in fact over all of Europe this American species is considered to include two distinct species and one variety, that is, *P. douglasii* Carr., commonly called coast, Pacific Coast, Oregon, or green Douglas fir; *P. glauca* Mayr. known as mountain, Rocky Mountain, Colorado, or blue Douglas fir; and *P. douglasii* Carr. var. *caesia* Schwer., termed Fraser River or intermountain Douglas fir. The name Fraser River is an unfortunate misnomer, since the Fraser River has its source in the northern Rocky Mountains and empties in the Pacific Ocean, so that green Douglas fir as well as the intermountain variety are found along its banks, and probably the blue Douglas fir besides.

It is not within the province of this paper to discuss the relative merits of the American and European species-concepts of Douglas fir. The latter has been well presented by Henry and Flood (8) and Hickel (9). Suffice it to say that the two species as recognized in Europe are at least biologically so different, particularly in their rate of growth and reaction to disease, that in this paper it seems advisable to adopt the European classification for the sake of clarity.

The British also subdivide certain other species of American conifers, and in other cases the specific name used is not in accordance with the one accepted here. A table of synonyms for a few of the more important species on which there is a difference of opinion follows:

AMERICAN NAME	BRITISH NAME
Abies concolor	*Abies concolor*
White fir	Colorado white fir
A. concolor lowiana	*A. lowiana*
Pacific white fir	Low's white fir
A. lasiocarpa	*A. sub-alpina*
Alpine fir	Alpine fir
Pinus contorta	*Pinus contorta*
Lodgepole pine	Beach pine
	P. murrayana
	Lodgepole pine

P. radiata	*P. insignis*
Monterey pine	Insignis pine
Tsuga heterophylla	*Tsuga albertiana*
Western hemlock	Hemlock spruce

IMPORTANT DISEASES

Canker

A most important disease primarily of Douglas fir is canker, presumably caused by *Phomopsis pseudotsugae* Wilson. The effect of this fungus on the host, resulting in die-back of the young shoots and canker of the stems, has recently been adequately described and figured by Wilson (27). The parasite has probably been present in Europe under various names for many years but it is only recently that it has received serious consideration, when with the extensive planting of Douglas fir in Great Britain the damage caused by the fungus has become appreciable. Rostrup (19), in 1890, described *Phoma pithya* Sacc., which he considered identical with *Phoma abietina* Hart., attacking the shoots of Douglas fir and silver fir in Denmark, and in 1906 (20) listed it from Bornholm, a small island in the Baltic Sea about 100 miles east of Copenhagen. However, specimens collected on this island by the writer in September, 1925, from Douglas fir, said by the head forester to be infected with *Phoma pithya*, were found upon critical study to be attacked by *Phomopsis pseudotsugae*. Böhm (1), in 1896, described and figured a canker disease on Douglas fir in Germany which he attributed to *Phoma abietina*, but which from his description is the same as *Phomopsis pseudotsugae* in its effect on the host. Somerville (22) mentions *Phoma pithya* on Douglas fir in Scotland as early as 1898. Hickel (9, p. 31), mentioning the diseases of Douglas fir in Europe, lists *Phoma pithya*, *P. abietina*, and *Phomopsis pseudotsugae* as synonymous; while Visart and Bommer (24, p. 302) report *Phoma pithya* on Douglas fir in Belgium. De Koning (13), in 1922, records *Phoma pithya* on Douglas fir in Holland. In France, Prillieux and Delacroix (18), in 1890, described *Fusicoccum abietinum* (Hart.) P. and D. on silver fir which later was shown to be identical with *Phoma abietina*.

Wilson (27, pp. 13, 28–31), in his bulletin on *Phomopsis pseudotsugae*, recorded the fungus on Douglas fir and Japanese larch, cited a single instance on European larch, and reported one of *Diaporthe pithya* Sacc., presumably the ascigerous stage of *P. pseudotsugae*, attacking lowland white fir (*Abies grandis*). Wilson separates the species on the following basis.

> *Phoma abietina* (from specimen determined by Hartig). With sporophores, conidia 12–14 × 5–6 μ, somewhat angular in outline.

Phomopsis pseudotsugae (from specimens). With sporophores, conidia 5.5–8.5 × 2.5 μ, regular in outline.

Phoma pithya (from description only). No sporophores.

There is also a difference in the structure of the pycnidium of *Phomopsis pseudotsugae* and *Phoma pithya*. A critical study of the type collection of *P. pithya* may show it to be identical with *Phomopsis pseudotsugae*.

The three species are so closely related that they have been badly confused. It will require intensive work to straighten out the present confusion in nomenclature in order to determine the history and distribution of *Phomopsis pseudotsugae* in Europe. The fungus is actually present in Great Britain and Denmark, and for practical purposes it must be considered as present in Germany, Holland, Belgium, and France. In Great Britain the canker was found to be much more common in the comparatively moist, cool regions of Wales and Scotland than it was in the dry, warm parts of England such as Norfolk, Suffolk, and Hampshire. This indicates that the disease will be found more widespread in northern than in southern Europe. As yet the fungus is not known in North America, although Hahn (6) has recently found another *Phomopsis* on Douglas fir in nurseries in the eastern United States. This investigator is now in Great Britain studying the problem further.

So far, the canker is essentially a disease of young trees, and no indications of it have been found on large, mature individuals. Furthermore, it is practically confined to the green form and rarely attacks blue Douglas fir. This was strikingly apparent in the infection on Bornholm. Quite severe damage has occurred in plantations, just after the trees have been set out, by the killing back of the leading shoot, resulting either in the death of the tree or a bunchy-topped, slow-growing survivor. Larger trees may be killed by the canker girdling the stem, but no tree over 2 inches diameter breast-high was seen killed in this way. As a rule most trees which have succumbed were less than 8 feet in height. The largest tree seen with a stem canker was 8 inches diameter breast-high just above the canker. This was in Denmark.

There are two ways in which stem cankers originate: through the tip infection of a living lateral with subsequent spread to the stem, and by direct inoculation of the stem through a wound. There is no evidence that infection can occur through uninjured bark. While the former method of infection on the stem of seedlings and small saplings is not uncommon, it is not frequent in stands varying from the large sapling to small pole size where very few living lateral shoots are to be found on the lower stems, the branches having been uniformly killed by shading. In such stands wounding is all-important: without wounds the trees remain practically

free from canker. Wounding, nearly always the result of human carelessness, can be prevented and the canker on stems of trees from large sapling to small pole sizes largely controlled. The two worst cases of stem cankers observed were in Wales, where a stand of large saplings had been badly wounded by pruning, and on Bornholm, Denmark, where many wounds had occurred from thinning. In both plantations practically every wound had resulted in a canker.

The Japanese larch was occasionally found attacked by *Phomopsis pseudotsugae*, but always in plantations that had been pruned or thinned. Only one form of the disease was seen, that is, cankers on the main stem. No killed trees were noted. No die-back of the tops or branches was observed. The cankers on Japanese larch are not quite like those on Douglas fir. The most striking difference was that of greater size, the cankers on larch sometimes having a vertical extent of 2 feet, while those on Douglas fir rarely exceeded 8 inches. Furthermore, the margins of the cankers on larch were marked by a pronounced exudation of resin.

This parasite would be an extremely dangerous one, capable of killing trees up to a considerable size except for the fact that canker development persists only through the winter and spring following infection and apparently stops completely when the host resumes active growth in the spring. It is noteworthy that the fungus *Neofabrea malicorticis* (Cordley) Jackson, causing a similar canker on apple trees in the Pacific Northwest, behaves in the same way (12, pp. 178–179). Wilson (27, p. 21) reports a single exception to the foregoing habit—the case of a canker which continued development over a four-year period. Since the cankers develop rather slowly, particularly horizontally, it is possible for only a rather small stem to be girdled, unless several cankers coalesce, which does not often happen.

The most serious damage seen by the writer was near Murthly, Scotland, where a plantation of 10- to 11-year-old Douglas firs was only about 50 per cent stocked, on account of killing by *Phomopsis pseudotsugae* during the years 1920–1922. The bare spots had been replanted in 1921, but most of the new trees had been immediately killed. This is a very serious loss, judged even by present American standards which are necessarily less rigorous than European ones.

Our standard is a fully stocked stand at maturity, so that any disease which does not reduce the final stocking or the increment can not now be considered of importance, since thinning is not economically practicable. But in Great Britain, where it is hoped to realize on thinnings, the death of any young trees in a plantation is a loss, particularly when planting costs due to drainage work, cutting ferns and brambles, and rabbit fencing, trapping or shooting amount to from 4 to 10 pounds (approximately 20 to 50 dollars) per acre, as contrasted with 15 dollars on national forests in the Pacific Northwest.

But in most of the infected areas seen throughout Great Britain the actual damage would be considered slight if occurring in stands of identical age and size in the Douglas fir region of the Pacific Coast. Nevertheless this parasite must be considered a serious potential danger to the Douglas fir in North America, for enough was seen in Great Britain of the virulence and change in life habits of imported parasites more or less innocuous in their native haunts to realize that in general it is hazardous to predict what any fungus will do in a new environment. To be sure, the artificially created (planted) stands of Europe are inherently more subject to disease than the naturally regenerated stands of western North America, but, on the other hand, the discontinuous nature of the stands abroad is in itself a measure of protection against parasitic attack, while the continuous area of practically pure Douglas fir extending over hundreds of square miles in this country is an ideal situation for an epidemic. Considering the fact that Douglas fir at present comprises about one-fourth of all the merchantable timber in the United States and will always occupy a highly important position, there is much at stake.

Consequently this disease must be studied further. It is not yet proved by inoculations that Douglas fir canker is actually caused by *Phomopsis pseudotsugae*, the evidence so far being constant association of the organism with the disease—excellent as far as it goes. However, information is not complete on the method of infection, origin of the disease, its original host, its present distribution, and its relation to somewhat similar diseases which have figured in European literature. The origin of the fungus is extremely important. If it could be proved that it came from the Douglas fir region of North America, our problem would be solved: the parasite would no longer be a potential danger. In the writer's experience in the Douglas fir region, nothing similar has been seen, and it is his reluctant opinion that the organism is a European or other foreign fungus, normally saprophytic, which has become parasitic on two introduced species, Douglas fir and Japanese larch.

Needle Cast of Douglas Fir

Needle cast caused by *Rhabdocline pseudotsugae* Syd., first described by Weir (26) and later named by Sydow (23, pp. 194–195), has so far been reported in Europe at only two places—near Stobo, Peeblesshire, Scotland, and at a point 8 miles distant to which it has apparently spread from Stobo (29). The fungus was probably brought in directly from western North America where it is ubiquitous, since importations of Douglas fir have been made in the past to the place where the parasite was found.

The disease seemed even more virulent than in America, a heavy attack of it for four successive years having reduced the height growth of the most

severely attacked trees to a few inches per season. The intermountain Douglas fir was most severely injured, followed by the blue variety, while the valuable green form was not affected. If the parasite continues in this way, neglecting green Douglas fir, it will not cause much damage in Great Britain, since planting of the other two varieties of Douglas fir will be very restricted owing to their slow growth. There is of course a continual danger that a strain of the fungus to which the green Douglas fir is susceptible may be imported or that the present strain may ultimately adapt itself to the green form.

Douglas Fir Aphid

The most serious injury to green Douglas fir observed was caused by the aphid (*Chermes cooleyi* Gill.). This insect, originally imported from North America where it occurs throughout the range of Douglas fir, was found in greater or less degree in practically every Douglas fir plantation visited in Great Britain. It was not noticed on the island of Bornholm in Denmark. It has been described by Chrystal and Storey (3).

The insect rarely, if ever, kills the trees attacked, but where infestation is heavy there is a decided suppressing effect on individuals and stands. No trees escape in a heavy infestation. One plantation of trees from 10 to 15 feet high which normally grew from 15 to 36 inches per annum has been reduced for the past two years to an average annual height growth of from 3 to 6 inches. In another plantation of Douglas fir mixed with western red cedar the first named species was badly overtopped by the latter, due to *Chermes cooleyi* on the Douglas fir, while under normal conditions the Douglas fir would have grown much faster than the cedar. Infestation was always most severe in open stands or on the marginal trees in dense stands.

This insect in Great Britain is another classic example of a marked change in life habits of a parasite in a new environment. In North America it is practically innocuous, while in Great Britain it has become extremely virulent on the green Douglas fir only, rarely being found on the blue form. Furthermore, in America it also attacks Sitka spruce, causing cone-like galls on the twigs and at times severely injuring young trees, but in Britain the Sitka spruce strain has not yet been found, although young Sitka spruce is growing in many places immediately adjacent to or in the immediate vicinity of infested Douglas fir. Of course there is still some doubt as to whether the form on Douglas fir and the gall-causing form on spruce are actually one species.

Just what the future of this parasite in Great Britain will be is problematical, but from present indications, when the epidemic gains momentum, the consequences will be serious. Even though older plantations may be little affected by the attack, there will be a marked reduction extending over

several years or more in the annual increment of younger plantations, necessitating a corresponding increase in the rotation. Hope of control lies in the introduction from North America of the natural parasites of the insect and the selection of favorable sites for Douglas fir plantations.

Silver Fir Aphid

The silver fir aphid (*Dreyfusia nuesslini* Börner) was apparently introduced into Great Britain from Continental Europe where it is widely distributed but not exceedingly virulent on silver fir. In 1925 the aphid was widespread in Britain, the damage to silver fir being so severe that the further planting of this species may have to be discontinued.

Needle and Twig Blight of Firs

Rehmiellopsis bohemica Bub. and Kab., recently discussed by Wilson and MacDonald (28), attacks the needles of the current year on several of the true firs. In severe infections the majority of the season's needles on each shoot are killed, resulting in the death of the shoot during the course of the growing season. If a severe attack is sustained over several seasons the stand is badly injured and many trees may die.

This was the case with a young stand of silver fir at Inverliever, Scotland. Here the fungus, working in combination with the silver fir aphid, was so steadily killing a stand of young trees up to 20 feet high that in a few years the entire stand would be wiped out. These trees, however, were on a very unfavorable site, which in the writer's judgment had much to do with the sustained intensity of the attack. On Bornholm, where silver fir is grown extensively on good sites, there had been an epidemic of this fungus during the 1924 season, but for some years previous it had been little in evidence, and an examination in September, 1925, showed that the summer's attack had been very light.

The only American species found attacked by *Rehmiellopsis bohemica* was noble fir. A small plantation on a poor site in Scotland was being severely injured in spite of attempts at control by cutting out the diseased portions. The aphid was not present on these trees.

Needle and Twig Blight of Pines

At various places in Scotland certain pines were suffering rather severely from needle and twig blight of pines caused by *Brunchorstia destruens* Eriks., which appeared to be spreading. The fungus was described on the continent years ago by Brunchorst (2) and Schwarz (21), the latter considering it to be the imperfect form of *Cenangium abietis* (Pers.) Duby, but it has only recently come under Dr. Wilson's observation in Great Britain.

At one place in Scotland where the parasite was observed, Swiss stone pine (*Pinus cembra* L.) was being so badly damaged that it seemed only a question of time until this species would be eliminated from the locality. The fungus was killing the tops and branch tips of the trees from 5 to 20 feet high to such an extent (the oldest about 25 years old) that many were dying and all were in more or less unhealthy condition. Swiss mountain pine (*P. montana* Mill.), western white pine (*P. monticola* Dougl.) and lodgepole pine were attacked, although not so severely as stone pine. The trees were all occupying a very poor site.

On another estate Corsican pine was being severely injured, while the mountain pine was less seriously affected.

White Pine Blister Rust

Very little white pine blister rust (*Cronartium ribicola* Fisch.) on 5-needle pines was seen in Great Britain, for there were relatively few pines of this group to be found. The disease was abundant in places on cultivated black currant (*Ribes nigrum* L.). Planting of 5-needle pines has been definitely abandoned because of blister rust, the opinion of British foresters being that it was poor policy to plant any species that would have an added charge against it for protection, when other species could be substituted. In the writer's opinion, there are places in Great Britain where 5-needle pines can be grown with little or no increased cost because, on the whole, wild currants or gooseberries were found to be rare.

On the island of Bornholm in Denmark, eastern white pine (*Pinus strobus* L.) was badly damaged by blister rust. No wild currants or gooseberries were seen; infection came entirely from European black currants in farm gardens at distances of 300 to 3,300 feet from the pines, no difference in degree of infection of the white pines being apparent as the distance from the currants increased. This locality afforded the most valuable evidence of the terrific damaging power of the European black currant. This currant can not be tolerated in a region where white pines are grown.

Needle Cast of Larch

Needle cast, very common on young European larch throughout Great Britain, is caused by the fungus *Meria laricis* Vuill. It results in the death of needles on young trees and particularly of the young needles on the long shoots. It was most serious in nurseries, where heavy losses have occurred during the past few years, seedlings and transplants being killed by defoliation. The fungus in Great Britain has been described by Hiley (11).

Larch Canker

In the past, canker on European larch caused by *Dasyscypha calycina* (Schum.) Frick. had been so destructive in Great Britain that the future

cultural value of this tree seemed very uncertain. In fact considerable damage is still being done. This disease has been described by Hiley (10, pp. 16–79).

But foresters, in the light of long experience, now feel that in the main this disease can be controlled by proper silvicultural methods. Larch has been planted indiscriminately on all types of site; it has been planted too thickly and stands have been allowed to stagnate. By avoidance of low, poorly drained sites, by wider spacing and judicious mixture in planting, and by early thinning in order to admit plenty of light and air, it is believed that relatively healthy stands of European larch can now be grown.

Cedar Leaf-Blight

Leaf-blight of western red cedar caused by *Keithia thujina*, which has been discussed by Weir (25), has been found during the past few years at a number of widely isolated points in England, Scotland, and Ireland (4, 5, 14, 16, and 17). As yet little is known as to what it may do, but so far wherever it has occurred it has been extremely severe. The parasite was apparently introduced from America, but the British authorities are somewhat puzzled by its sudden appearance in remote localities where no nursery stock has been known to have been introduced.

Root Rots

The two important root rots were caused by the honey fungus (*Armillaria mellea* (Vahl.) Quel.) and by *Fomes annosus* (Fr.) Cke.

The honey fungus seemed to attack all species and sizes of conifers although young trees in the sapling stage were most susceptible. It was particularly bad in plantations of conifers on cut-over areas previously occupied by old, overmature stands of oak. Much oak forest in Britain is being converted into softwoods. Corsican pine was by far the most susceptible of all the conifers observed.

Fomes annosus was also found attacking various species of conifers, being particularly severe on Norway spruce, silver fir, and Douglas fir. While trees up to 6 inches diameter breast-high and larger were seen which had been killed by the fungus, those in the sapling stage suffered most. Japanese larch was not immune from this fungus.

Chestnut Blight

The discovery of *Endothia parasitica* (Murr.) A. and A. on chestnut in Belgium and on a staging pole in London by Metcalf (15) in 1923 indicated that the fungus might be present in Great Britain, but, although chestnut was examined at various places, the disease was not found. The chestnut orchards in Kent were not visited.

The foregoing discussion on a few important forest tree diseases is merely to call attention to some parasites in Great Britain which are potentially dangerous to this country and to present examples of how introduced parasites can change their habits, particularly their virulence, in a new environment.

STRAINS OF FOREST PARASITES

Even a superficial study of forest tree diseases in Europe, particularly those introduced from North America, clearly points to the existence and importance of strains, biological species, or physiological species in forest tree parasites. Among the European organisms Hiley (10, p. 79) mentions two different growth forms of larch canker (*Dasyscypha calycina*), a saprophytic and a parasitic form.

Throughout the native range of Douglas fir the needle-cast fungus is found. In Scotland the fungus was attacking only the blue and intermountain varieties, neglecting the green. The Douglas fir aphid, on the other hand, so far has virtually confined itself to green Douglas fir throughout Great Britain, very rarely being found on the blue form, while in its native home it infests all forms of the host. *Phomopsis pseudotsugae*, presumably a native to Europe, was not found attacking blue Douglas fir, although it occasionally does, but was common enough on green Douglas fir.

Fomes annosus was commonly killing young conifers in Great Britain and Denmark. This fungus is often found in the Pacific Northwest on old stumps or dead trees and occasionally causes root rot and butt rot in a mature tree, but it very rarely infects young trees.

Black poplar (*Populus trichocarpa* T. and G.) in the Pacific Northwest is commonly infected by the yellow leaf blister caused by *Taphrina aurea* (Pers.) Fr., which is also found on the Lombardy poplar (*P. nigra* L. var. *italica*) in the same region but frequently not in the same locality. The fungus was observed in a nursery in Scotland on the leaves of saplings of *P. generosa* Henry, *P. laurifolia* Led., and *P. nigra*, about 4 feet high. *P. nigra* was most heavily infected. *P. trichocarpa* in the same block and with its leaves intermingled with the diseased *P. generosa* was absolutely free from infection.

The foregoing conditions show clearly that strains do exist in certain species which are represented in America, on the polymorphism of which there is little or no information. It is, of course, much easier to see this in Great Britain, where the various growth forms of conifers of wide distribution are planted side by side, than it is in America, where the species occur naturally over thousands of square miles and direct comparison is rarely possible. These conditions also indicate a pathological as well as a

morphological basis for the separation of Douglas fir into two distinct species as is done by the British.

QUARANTINE PROTECTION

In the past, forest trees, particularly conifers, have been imported indiscriminately into Great Britain from all over the world, and in some measure this is still going on. Neither the quarantine laws nor the inspection force are adequate, while there are the usual difficulties in properly enforcing such laws as do exist.

Fortunately, or unfortunately, Great Britain has never had a disastrous plant disease epidemic. If she had, the country might be awake to the need for more careful regulation of the importation of nursery stock. The elm disease, probably caused by bacteria (*Micrococcus ulmi*) and probably introduced during the World War, is now rapidly killing the trees in Holland and nearby sections of Germany, Belgium, and France, but has not yet crossed the channel.

But some very dangerous diseases have been brought in. From North America have come the Douglas fir aphid and the Douglas fir needle cast, the former already wide-spread and serious on, and the latter potentially dangerous to, Douglas fir, while the cedar leaf-blight is becoming increasingly bad on western red cedar. From continental Europe the silver fir aphid has arrived.

It would seem that the discontinuous nature of the stands would greatly retard the spread of those diseases practically confined to one host species. This would probably be so except for the indiscriminate movement of nursery stock about Great Britain and Ireland, in some cases even when it is known to be diseased. Great Britain, occupying an isolated island, has had a good opportunity to keep her forests free from foreign parasites. This chance has been largely lost by the unregulated importation of young trees.

There is a lesson for the United States in this. Our quarantines are the only safeguard that will prevent the introduction of several known, potentially dangerous forest tree diseases and undoubtedly many of which we have no knowledge. Any weakening of our quarantine laws or policy will result in increased future expenditure for control. Another point of primary importance must be considered. It may be just as dangerous to introduce a foreign strain of an indigenous parasite as it would be to let a new species come in. For example, the strain of *Fomes annosus* observed in Great Britain, if introduced into the Douglas fir region of the Pacific Northwest, might prove highly virulent, whereas the fungus as it exists there at present is of trivial importance.

FACTORS FAVORING DISEASE

In silviculture in Europe, and particularly in Great Britain, certain practices are common which predispose stands to diseases of epidemic character. It is axiomatic in crop production that intensive culture increases the danger from disease, and timber growing in western Europe is decidedly intensive.

Clear cutting followed by planting, almost universal in Great Britain, in itself predisposes stands to attack by fungus and insect parasites. In Denmark natural regeneration is practiced wherever possible, and it was noteworthy that Skovrider K. Bramsen, in charge of the state forest of Almindingen, repeatedly emphasized the greater amount of disease, particularly root rot caused by *Fomes annosus*, in the planted stands as compared to those established by natural regeneration. In Switzerland clear cutting is prohibited by law. The complete and sudden exposure of the forest soil resulting from clear cutting is considered very detrimental, resulting in a continuous lowering of the thrift of the timber crop over successive rotations.

In addition, on private holdings the British are tending toward a short rotation, as low as 40 years where possible. Furthermore, species are planted pure to a large extent, although foresters are striving more and more to find suitable mixtures. Pure stands are the most susceptible to fungus and insect attacks, consequently much of the woodland in Great Britain, consisting of pure planted stands managed on a short rotation and clear cut with the consequent exposure of the forest soil at more frequent intervals, is inherently susceptible to disease. The present silvicultural and economic ills of the pure, planted Norway spruce forests of Saxony are a classic example of the price that may finally have to be paid for continuous clear cutting and planting of a single species on a short rotation.

Proper selection of site is also very important. Since most of the conifers grown in Europe have been introduced from other regions, it was not known to just which sites the various species would be adapted, and at first little attention was paid to this. The results in many cases were disastrous. Stands on unsuitable sites grew slowly, were not thrifty, and sooner or later largely succumbed to insect or fungus attack. This has been well illustrated by Scotch pine, European larch, and silver fir.

Larch planted in dense, pure stands on low, moist or otherwise unfavorable sites with poor soil suffered severely from larch canker, while stands on favorable sites with good soil remained practically free from disease. To be sure it is not always possible to determine immediately the most suitable site for an introduced species, but sometimes even reasonable care has not been taken. A young stand of silver fir was seen in Scotland planted

on an exposed site in very poorly drained peat soil. The trees were rapidly being destroyed by two needle and shoot parasites, *Rehmiellopsis bohemica* and *Dreyfusia nuesslini*. Again in Wales, Douglas fir was found planted in soil only about a foot deep with an underlying, impervious, clay subsoil. The trees about 10 to 15 feet high were so far thrifty and growing rapidly, but it is a reasonable prediction that before many years there will be heavy losses in this stand from uprooting by wind or wet snow, if nothing else. Already damage by the latter has begun. In addition, the stand will ultimately stagnate.

The source of seed is another factor which has been too little considered in the past, but British foresters now feel that the inferiority of some of the present stands of Scotch pine and European larch is due to the fact that the seed came from localities on the Continent well outside the range for the optimum development of the species. Such inferior stands, of course, are quite susceptible to disease—for example, the susceptibility of the larch to canker. This general principle must be recognized and carefully considered for all species.

So far in America it has not been necessary in most forest regions to consider seriously the questions discussed above, but as silviculture here becomes more intensive and European practice is approached, the same difficulties will arise in some cases. However, as long as the majority of our managed forests of the future in this country are composed of native species naturally regenerated, with as little deviation from the original composition of the stand as possible, losses here from indigenous parasites should not be excessive.

CONCLUSION

There is one great lesson for American forestry in the existing situation in Great Britain: protect our native species.

The introduction of foreign nursery stock is a most dangerous practice; it may at any time result in another disastrous epidemic similar to chestnut blight or white pine blister rust. Foreign species should be introduced only as seed and the stock grown here. But any exotic tree is an uncertain quantity and if introduced should be grown only experimentally for a long term of years, for it is not until the end of the rotation that final judgment can be rendered as to the success or failure of an introduction. First, there is the problem of securing seed of the best quality from the optimum, native range of the species; second, the difficulty of proper site selection; and, finally, the possibility that the species sometime in its life may be attacked by an indigenous parasite hitherto innocuous. Any one of these factors can spell failure. For the native species, seed collection plays a minor part since natural regeneration is depended on mostly, the optimum sites are

known, and the indigenous parasites, while quite severe in some cases, never threaten the existence of any species. Those who suggest introducing a foreign species to replace a native tree already attacked by disease, instead of protecting the latter, if that is possible, are in a large measure advocating deferred trouble.

The introduction of an exotic tree species is, on the whole, a hazardous undertaking, but it is far more so in this country than in Europe, owing to our extremely inadequate knowledge of the suitability of foreign species to the various forest regions of the United States. Abroad, different exotic tree species had been grown in arboreta for a long time before they were established as components of the forest. This was particularly true in Great Britain, and is a practice which should be generally initiated at once by our own country where there are few arboreta, especially in the western states. Costing little to start or maintain, an arboretum nevertheless requires a long time to develop, since raising trees from seed is a slow process, and complete results can not be expected until the trees are mature. Arboreta or experimental plantings for testing exotic species should be maintained by all the forest schools and forest experiment stations. No other activity will yield a greater commensurate reward for the expenditure involved. In the future, circumstances which can not be foreseen or controlled may compel the widespread establishment of a foreign tree species. Only with knowledge gained from arboreta and experimental plantings can such a situation be adequately met.

Finally, by carefully following literature, corresponding with foreign workers, and actually studying conditions on the ground in those countries most closely united commercially with our own, forest pathologists in this country must obtain an extensive knowledge of exotic diseases of trees. In this way, if a foreign parasite is introduced, and we already have a knowledge of its life history and habits, priceless time can be saved in its detection and the initiation of eradication or control measures. The value of such information at the outset of the white pine blister rust or the chestnut blight epidemics, for example, would have been beyond estimation.

SUMMARY

1. This paper presents observations during 1925 on the pathological condition of various conifers introduced into Great Britain and Denmark, particularly species from the western United States.

2. Douglas fir is attacked by *Phomopsis pseudotsugae, Rhabdocline pseudotsugae,* and *Chermes cooleyi;* silver fir suffers severely from *Dreyfusia nuesslini;* various true firs are injured by *Rehmiellopsis bohemica;* while pines are damaged by *Brunchorstia destruens.*

3. In Great Britain planting of 5-needle pines has been discontinued on account of the ravages of *Cronartium ribicola;* and on the island of Bornholm, in Denmark, eastern white pine was found severely infected by this rust. Nursery stock of European larch is commonly defoliated partially or completely by *Meria laricis,* while the older trees are frequently cankered by *Dasyscypha calycina.* Western red cedar is attacked by *Keithia thujina,* causing leaf blight. Root rots caused by *Armillaria mellea* and *Fomes annosus* are common on conifers.

4. The existence of strains of certain forest tree parasites not regarded as polymorphic in North America is quite apparent in Great Britain.

5. Several dangerous forest tree diseases have been brought into Great Britain, which indicates the need for careful regulation of the importation of nursery stock.

6. Certain practices, such as the culture of pure stands of one species on a short rotation followed by clear cutting, predispose stands to disease. In addition, plantations have sometimes been established on poor sites. The source of seed also has not always received proper consideration.

7. Foreign species should be introduced into the United States only as seed and the stock grown here. But even this is hazardous, since the species may become subject to the attack of an indigenous parasite; consequently there is need for the establishment of extensive arboreta throughout the forest regions of this country where the behavior of exotic species can be studied.

8. Finally, forest pathologists in this country must obtain an extensive knowledge of exotic parasites on trees in order to safeguard our forests.

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A WITCHES' BROOM OF INTRODUCED JAPANESE CHERRY TREES

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INTRODUCTION

About 60 years ago the first Japanese cherry trees were imported into the United States, but few of them became established here at that time because the principal method of propagation which was tried involved grafting and budding them upon *Prunus avium* Linn. and *P. cerasus* Linn. which are not suitable grafting stock for Japanese cherries (24). Subsequently small numbers of them were obtained direct from Japan or through European nurseries (17). In 1906 (17) 25 varieties were imported by Dr. David Fairchild, who planted them at his home near Chevy Chase, Maryland. In 1912 shipments of 12 varieties of Japanese cherry trees were presented by the city of Tokyo to Mrs. Taft for the city of Washington (17, 19). These varieties (Mazakura, Yoshino, Shirayuki, Ariake, Mikurumugaeshi, Gyoiko, Fukurokuju, Ichiyo, Kwanzan, Takinioi, Fugenzo, and Jonioi) are described by Russell (17). According to a letter from him they are distributed in three Prunus species (*P. lannesiana* Wilson, *P. serrulata* Lindl., and *P. yedoensis* Mat.), which are described by Wilson (24). Over 2,000 of these trees, about half of which belonged to the Yoshino variety, were planted in Potomac Park, Washington, D. C., where they have grown very vigorously. A few Japanese cherry trees are growing in other parks and in private grounds in the District of Columbia, and some have also been planted as street trees in Chevy Chase, Maryland. Collections of them in other parts of the country are listed by Russell (17), and some varieties are now being sold by several nurseries. Since Japanese cherry trees constitute a real contribution to American horticulture, a discussion is not amiss of a witches' broom disease which was introduced with them before the enactment of our present plant quarantine laws.

Observations on this witches' broom at Washington were begun in 1917, after attention was called to it by Dr. T. Tanaka. The causal fungus appears to be *Exoascus cerasi* (Fuckel) Sadebeck.[2]

[1] The writer wishes to acknowledge the assistance of Dr. Carl Hartley and Mr. G. G. Hahn in collecting the data for this article.

[2] Miss Anna E. Jenkins, of the Office of Pathological Collections, made this determination from preserved mounts of stained sections prepared by G. G. Hahn from specimens of the disease on *Prunus yedoensis* which he collected in Potomac Park, Washington, D. C., on April 17, 1917. She was unable to compare these sections with those of an authentic specimen of *Exoascus cerasi* (Fuckel) Sadebeck, as such was not available but she found that the characters of this fungus agreed with published descriptions of it.

SYMPTOMS OF THE DISEASE

Japanese cherry trees when infected throughout have peculiar bunchy crowns (Fig. 1). Infected twigs bear no flowers but produce leaves earlier than uninfected ones. These leaves are undersized, much crinkled, and slightly discolored. About a week after the uninfected portions of the

FIG. 1. A Japanese cherry tree which had been transformed entirely into a witches' broom by *Exoascus cerasi*. The trees in the background were normal. Photograph made in Potomac Park, Washington, D. C., in April, 1917.

trees begin to flower, the under surfaces of the crinkled parts of the infected leaves become covered with powdery, bloomlike, inconspicuous, fungous coatings—the spore-bearing layers. The spore-bearing parts of the leaves turn black rather promptly. Later in the season normal leaves are developed. Figure 1 shows a tree which has been transformed entirely into a witches' broom. The trees in the background are normal. Douglass (4), in a popular account of this disease, published additional pictures of the disease on the Japanese cherry. Other writers (8, 9, 11, 13) have described the witches' brooms which *Exoascus cerasi* causes on other species of *Prunus*.

THE DISEASE IN THE VICINITY OF WASHINGTON

On April 18, 1917, every Japanese cherry tree in Potomac Park was carefully examined for symptoms of the disease. Nineteen scattered trees, all belonging to the Yoshino variety (*Prunus yedoensis*), were infected.

This means that only a small percentage of this variety, and a still smaller percentage of the total number, were infected. Seventeen of the trees were infected throughout, the infection apparently having occurred before the trees were shipped from Japan, and the other two trees had been infected for a long time. A minute examination of the trees near the diseased ones revealed no evidence of infection. Since the trees are all grafted ones (19) it is entirely possible that the disease had been introduced into them by grafting.

Sixteen of the infected trees were immediately cut down, their roots dug up and the whole burned. Some of them appeared to be releasing spores at that time. Two others were heavily pruned, planted in tubs and grown for a time in the pathological greenhouses for observation. All spore-bearing leaves soon died, leaving only apparently healthy ones.

The nineteenth tree had apparently been infected throughout when shipped from Japan. A secondary main shoot had arisen later from the main axis. This shoot was growing vigorously and appeared to be entirely healthy. The diseased part of the tree was removed and burned and the remainder left standing.

Subsequent inspection in 1918 showed a small witches' broom on a tree of the Yoshino variety which had apparently become infected in 1916, four years after its introduction into America. Only 1916 and 1917 growths were visibly infected. This broom was cut off six inches back of the first healthy twig and burned before any spores had been disseminated. No other evidences of infection were seen. All cherry trees in the park were again inspected in 1919 and 1924, and those of the Yoshino variety in 1925, but no further signs of witches' broom were found.

Some witches' brooms had been removed from the Japanese cherry trees on the Fairchild estate prior to 1917 and no evidence of recurrence was noted in 1917. At that time another small broom was removed from one tree of the green flowering variety known as Asagi (*Prunus lannesiana*). In 1926 these trees were inspected again but no evidence of this disease was noted.

The Japanese cherry trees which are growing as street trees in Chevy Chase, Maryland, have remained free from the disease. None of the ornamental cherry trees in the other parks in the District of Columbia which were inspected in 1917 were visibly infected by *Exoascus cerasi*.

Except for the two places previously mentioned, the disease has not been reported near Washington, D. C.

THE DISEASE IN GENERAL

The writer has been able to learn little in regard to the distribution and importance of the witches' broom which *Exoascus cerasi* causes in Japan, because most of the papers on the disease there are written in the Japanese language. It occurs on *Prunus pseudo-cerasus* var. *spontanea* Maxim, *P. pseudo-cerasus* var. *suboldii* Maxim, *P. miqueliana* Maxim and *P. cerasus* L. (14). Heinricher (8) and Laubert (11) consider the disease neither destructive nor important in Europe, while Tubeuf (22, 23) says that it has assumed considerable economic importance there because every cherry tree in a fruit garden may be attacked by it and each tree may bear several brooms. Its hosts have been listed by Hesler and Whetzel (9), Encke (6) and others. The disease appears to be rare in England (3).

In the United States the presence of *Exoascus cerasi* was first reported in 1886 by Meehan (13) on an escaped cherry tree (*Prunus avium*) in Pennsylvania. Since then the disease has been reported from approximately half of the states but in most cases it has been described as occurring rarely, many of the reports being based upon the occurrence of one broom on one tree. However, according to Owens (15) and others (9, 10, 12), *E. cerasi* is very common in Washington and Oregon. The reported hosts for it seem to be *Prunus* sp. (1); *P. americana* (1, 16); *P. avium* (1, 13, 21); *P. cerasus* (1); *P. demissa* (1, 16); *P. emarginata* (18); *P. hortulana* (16); *P. pennsylvanica* (1, 16); *P. serotina* (1, 16); and *P. virginiana* (1). It is possible that some of the witches' brooms attributed to *E. cerasi* may have been caused by other fungi because other witches' brooms of cherry, such as those caused by *E. interstitiae* (2), also occur in this country and many of them were observed when they were not fruiting and apparently were not compared with authentic material of *E. cerasi*.

The facts that *Exoascus cerasi* was not reported in the United States until after the introduction of the first Japanese cherry trees and that the

first reported host was *Prunus avium*, one of the species which was used as grafting stock for them, are interesting although they may not be significant. *P. avium* is also one of the two most common hosts for *E. cerasi* in Europe (5). Whether the disease is native to this country is not known, but it is highly probable that it may originally have been introduced from either Europe or Japan.

There seems to have been little effort to eradicate systematically the witches' brooms from cherry trees in America (9) and few attempts even in the parts of Europe where the disease is considered of economic importance (22, 23). Duggar (5) recommends controlling the disease by spraying, while others (6, 9, 10, 12, 20) advise pruning and burning the diseased portions of the trees. Stevens and Hall (20) issue a warning against using portions of brooms in budding and grafting. These recommendations were made apparently as a result of general experience rather than as the result of specific experiments with *Exoascus cerasi*.

The attempts reported here to eradicate *Exoascus cerasi* from Japanese cherry trees seem to have been entirely successful despite the fact that in both cases the disease had been present and the pathogene probably sporulating for a number of years. The fact that *E. cerasi* was spreading slowly probably accounts for the immediate success of the eradication. Stewart (21) and others also have reported that the disease spreads very slowly in America, and Heinricher (8) and others that the same is true in Europe. It is very fortunate for cherry growers that, unlike *Endothia parasitica* (7) and some other introduced parasites, this introduced *Exoascus* has not found hosts or conditions which permitted more rapid spread.

SUMMARY

A witches' broom caused by *Exoascus cerasi* was introduced near Chevy Chase, Maryland, in 1906, and into the District of Columbia in 1912 on separate shipments of Japanese cherry trees. Most of the infections were on the Yoshino variety (*Prunus yedoensis*) but the Asagi variety (*P. lannesiana*) was also found infected.

Exoascus cerasi appears to spread very slowly in this locality. Probably because of this fact both of the above infections were easily and permanently eradicated by cutting out and burning the infected parts, although the disease in both cases had been present for several years before any attempt was made to eradicate it.

Reports of the occurrences of the disease in other localities are summarized.

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NOTES ON HIBISCUS DISEASES IN WEST JAVA

CARL HARTLEY

Until recently, most species of the genus *Hibiscus* received little attention from pathologists. The indices of the first 41 volumes of the Experiment Station Record list under *Hibiscus* only three references to disease. The interest in Java jute (*Hibiscus cannabinus*) and roselle (*H. sabdariffa*) as fiber sources has recently resulted in attention to their diseases in Malaysia. The writer wishes to place on record some data on them obtained in the experimental plantings of the Department van Landbouw incidentally to the investigation of some of the same diseases on peanuts for the Instituut voor Plantenziekten in 1921 and 1922.

The wilt or slime disease (*Bacterium solanacearum*) causes serious damage at Buitenzorg in an occasional field of *H. cannabinus*, but is never as serious as in peanut or tomato. The *Hibiscus* is very susceptible when young, but infected plants which live till they develop woody tissues in the stems make good recoveries. The relation of the bacteria found in *Hibiscus* to the strains of the same species which attack other hosts is discussed in a paper by Dr. M. B. Schwarz which is to appear as a Mededeeling of the Instituut voor Plantenziekten. This disease is known on *Hibiscus* in Deli (north Sumatra),[1] and what may be the same disease has been reported from the Malay Peninsula.[2]

Sclerotium rolfsii, or a near relative of it, is of rather frequent occurrence on *H. cannabinus* in the neighborhood of Buitenzorg. It was observed most frequently on plants whose early growth had been stunted by drought. Badly diseased plants appear to be weakened in general, have small leaves, and ultimately wilt; the abscission of lower leaves which occurs in plants attacked by *Bacterium solanacearum* is wanting. The lesions which are dry and show characteristic concentric red brown and pale gray brown zones, are sometimes found on the stems at considerable distances from the ground.

In a single instance there was observed a small local epidemic of another type of stem lesion on plants of *H. cannabinus* 25–30 cm. high. In contrast to the Sclerotium lesions these were gray and water-soaked, and immedi-

[1] JOCHEMS, S. C. J., and J. G. J. A. MAAS. Slijmziekte in de *Hibiscus cannabinus* op Sumatra's Oostkust. Teysmannia **33**: 542–546. 1922.

[2] EATON, B. J. Pests and diseases of plants. Agr. Bul. Federated Malay States **9**: 75–77. 1921.

ately produced in moist chamber a heavy coating of deep salmon pustules of hyalin spores ($13\frac{1}{2} \times 4\frac{1}{2}$ μ). This fungus was identified by Dr. A. Van Luijk as *Colletotrichum hibisci* Polacci.

Root knots were very abundant on *H. cannabinus* in parts of one planting. Nematodes in them were identified by Dr. R. Menzel as *Heterodera radicicola* Greeff. Eel worms on this species have also been reported from Malaya.[3]

In parts of a planting of *H. cannabinus* on the coast near Terisi the plants were reported by Mr. De Veer almost universally affected with rosettes at the tips of stems which had previously made normal growth. The leaves were normal, but internode lengths were reduced almost to zero. Some of the plants examined by the writer had recovered, and were developing new tips and resuming normal growth. No causal agent could be found.

On a green stemmed race of *H. sabdariffa altissima* at Buitenzorg Dr. A. Horst called to the writer's attention a leaf disease resembling closely that recently described and figured by Palm and Jochems in Deli, Sumatra.[4] The disease regularly began at the union of petiole and leaf-blade, and in Java tended to follow the veins. The death of all or a large part of the leaf blade usually resulted from a single lesion. Spread down the petiole was common, but not the killing of the main stem described on some of the plants from Deli. As appears to have been the case in Deli, most of the older leaves on the plants were destroyed by the disease, but too late in the season to hinder growth materially. The type of injury differed from that attributed to *Phoma sabdariffae*[5] in that the latter seems to have been primarily a stem parasite. In both Java and Sumatra the diseased leaf tissue was darkened by the great number of pyenidia which developed. At Deli the pyenidia contained spores, but those examined by the writer in Java had failed to mature. Apparently pure cultures of the Buitenzorg fungus were obtained from the interior tissue at the end of a petiole lesion. These cultures also failed to develop spores on either agar or steamed rice, though on both substrata great numbers of the sterile pyenidia were produced. The fungus was examined by Dr. Van Luijk but was not identified. One of the cultures was used in 1921 in preliminary inoculations on the green *H. sabdariffa altissima*, on a red stemmed strain of it on which the disease had not been found, and on *H. cannabinus*. Inoculum from a culture on rice

[3] EATON, B. J. *Loc. cit.*

[4] PALM, B. T., and S. C. J. JOCHEMS. Een bladziekte van roselle (*Phyllosticta* spec. op *Hibiscus sabdariffa* L.) Indische Culturen **10**: 391–393. 1925.

[5] REINKING, A. O. Philippine economic plant diseases. Philippine Jour. Sci. (A) **13**: 165–274. 1918.

was placed on the surfaces of the leaves and covered with wet cotton held in place by wire clips. Results were negative on *H. cannabinus* but positive on both varieties of *H. sabdariffa*. Positive results were secured most readily on leaves which had just unfolded. The lesions obtained produced the typical sterile pycnidia promptly. The experiments were controlled by parallel inoculations with a pink-spored fungus also isolated from dead *Hibiscus*. All of the control inoculations were negative.

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SWEET PEA FASCIATION, A FORM OF CROWNGALL

NELLIE A. BROWN

Fasciation of sweet pea plants has occurred in several successive years in some of the greenhouses of New Jersey. It has occurred in a greenhouse in New York State also, and a few plants of garden peas similarly affected have come to us from Maryland and Virginia. It generally appears during the rapidly growing period and before the heavy blossoming stage begins. Blossoming and full development are checked by it, and the plant becomes worthless to the florist or gardener. There is usually a main upright stem with normal leaves, on the crown of which a bunch of short, fleshy or wide stems is produced, giving the condition called fasciation. The fleshy stems give rise to misshapen and aborted leaves (Plate I, 1).

The thickened tissue was examined microscopically for fungi, bacteria, and nematodes, but none were found. Plates were poured from the thickened stems in the hope of isolating the crowngall organism. It proved to be present, and several colonies were picked off for inoculating. Typical conditions as they occurred in New Jersey were produced on sweet pea plants by one colony out of the four tried. (Plate I, 2 and 3.) The other three colonies were non-infectious. Inoculations with these three were made into 28 seedlings and 23 sweet pea plants.

The fasciation produced by inoculations was on the same variety of sweet pea, Zvolanek's rose, on which the disease occurred in New Jersey. The seed was purchased from an Eastern seedsman. The non-infectious colonies were tried on the same variety. The successful inoculations were made into seedlings which had been sprouted on moist blotting paper. Very fine punctures were made into the tender stems after which the seedlings were planted in pots. A very definite fasciation occurred on four out of eleven seedlings in from 40 to 60 days after inoculating. From these fasciations the organism was reisolated.

Inoculations made with the infectious colony into the crown of 14 sweet pea plants of the same variety when the plants were 5 to 8 inches tall did not produce a fasciated condition. Inoculations made into tobacco and geranium plants with the same colony were also negative. The organism seems to be in some respects a weak or highly specialized strain of *Bacterium tumefaciens*. It may be in the soil or may be carried on the

seed. If the disease has occurred once in a greenhouse, the soil should be disinfected or not used again for sweet peas.

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EXPLANATION OF PLATES

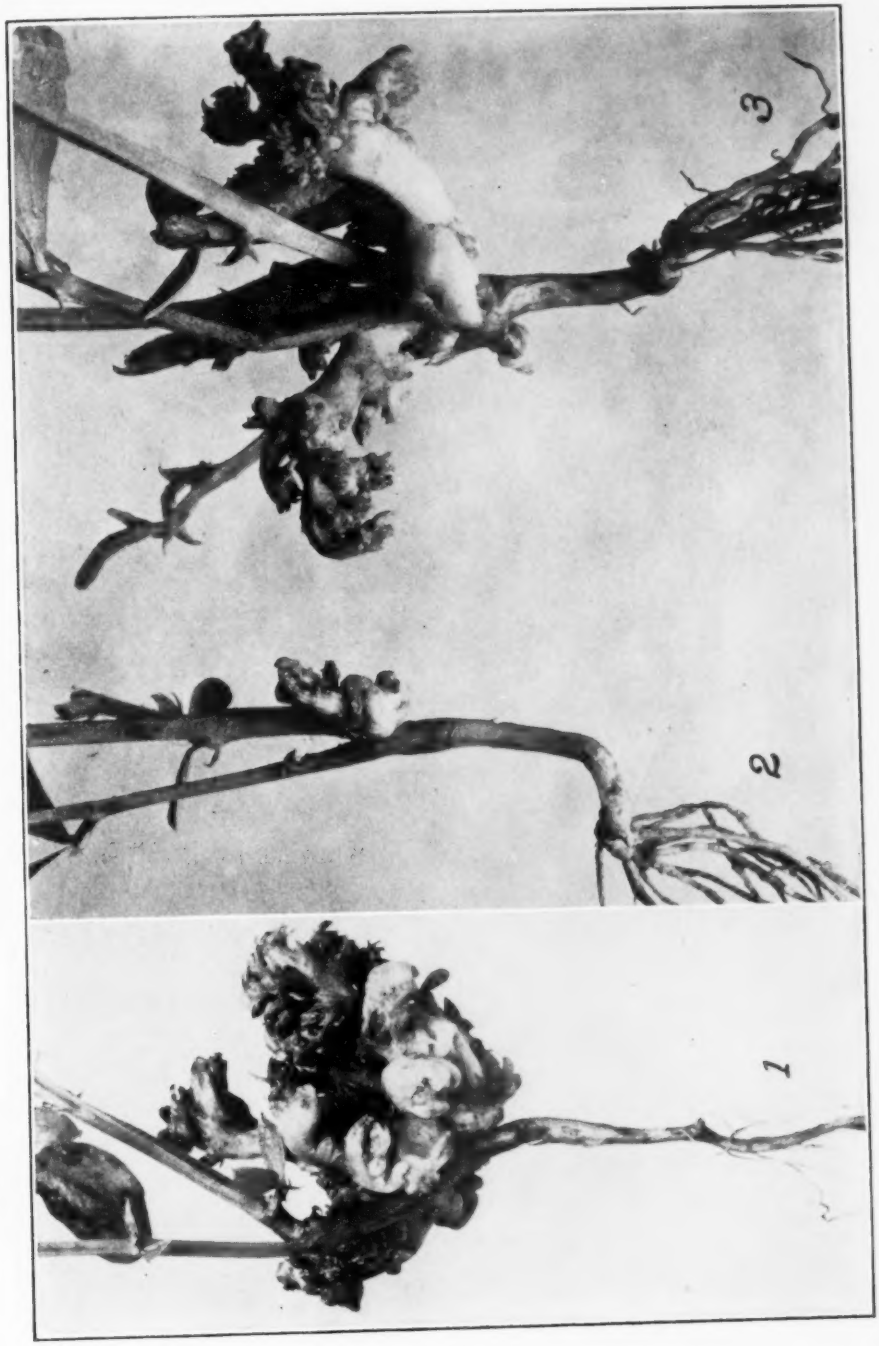
PLATE I

1. Sweet pea fasciation from New Jersey, enlarged about 1½ times.

2 and 3. Fasciations produced on sweet pea plants by inoculating with the crown-gall organism isolated from 1. Inoculations made April 24, 1926. Photographed, July 2, 1926. Enlarged about 2 times.

PLATE II

Fasciation on a second crop of sweetpea plants in the same New Jersey greenhouse. In some parts of the house as many as ten per cent of the plants were affected. Nematodes were also present in the house but this disease is not due to them. ×2 nearly.


3
2
1

Fasciation on a second crop of sweetpea plants in the same New Jersey greenhouse. In some parts of the house as many as ten per cent of the plants were affected. Nematodes were also present in the house but this disease is not due to them. ×2 nearly.

UNIV. OF MICH.

EFFECTS OF SOIL MOISTURE AND TEMPERATURE AND OF DEHULLING ON THE INFECTION OF OATS BY LOOSE AND COVERED SMUTS[1]

C. O. JOHNSTON[2]

In the experimental studies on smut of oats conducted at the Kansas Agricultural Experiment Station prior to 1924, it was constantly noted that smut infection never reached 100 per cent, no matter how heavily the seed was smutted. Infection in the hulled varieties seldom exceeded 50 per cent and in hull-less varieties it was seldom above 95 per cent. Other investigators have shown the marked dependence of smut infection in oats and barley on soil temperature and moisture and the absence of glumes. Some experiments were conducted at Manhattan, Kansas, in 1924 and 1925 to ascertain the importance of these factors on smut infection in oats under Kansas conditions.

MATERIAL AND METHODS

The seed used in these experiments was obtained from the Department of Agronomy, Kansas State Agricultural College. The varieties selected for the soil moisture and temperature studies, together with their usual reaction to smut as determined by experiments in preceding years, were as follows: Hull-less, Ks. 5201, very susceptible; Aurora, Ks. 5206, susceptible; Richland, Ks. 5209, moderately susceptible; Burt, Ks. 6004, moderately susceptible; Burt, Ks. 6090, resistant; and Kanota, Ks. 5179, resistant. All of these varieties, excepting Hull-less, are hulled oats and are of considerable economic importance. The same varieties, with the exception of the Hull-less, were used for the dehulling experiments. A selection of Kanota, with glumes only partially covering the caryopsis, was used in place of the Hull-less.

In the soil moisture and temperature experiment, half of the seed was inoculated with smut, the other half was clean. One row each of inoculated

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The author is greatly indebted to L. E. Melchers for helpful suggestions rendered in the course of these experiments. These studies have been conducted in cooperation with the Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture.

and uninoculated seed of each variety was sown on each date of sowing. In the dehulling experiment the glumes were removed from half of the seed of each variety, after which half of each of the hulled and dehulled samples of seed was inoculated. One row each of hulled-inoculated, hulled-uninoculated, dehulled-inoculated and dehulled-uninoculated seed of each variety was sown on each of two dates. Smutted and unsmutted samples of the same variety always were sown in adjacent rows, the unsmutted row thus serving as a check on the smutted row. All rows were 8 feet long.

The inoculum in both of these experiments was a mixture of about equal amounts of loose smut, *Ustilago avenae* (Pers.), and covered smut, *Ustilago levis* (Kell. and Sw.). The inoculum was prepared by grinding smutted panicles in a mortar and screening out all coarse chaff and seed. A quantity of the spores was added to the seed and the container vigorously shaken several minutes to give a uniform distribution of the spores. A very satisfactory covering of the seed with smut spores was thus obtained.

EFFECTS OF SOIL MOISTURE AND TEMPERATURE ON SMUT INFECTION

Jones (4) pointed out that spores of oat smut germinate best at optimum temperatures for the germination and growth of oats. Bartholomew and Jones (1) and Reed and Faris (5) found that a relatively low soil moisture content and high soil temperature were conducive to abundant smut infection. In order to determine the influence of soil temperature and moisture on the occurrence of smut infection at Manhattan, periodic sowings of oats were made throughout the season at intervals of about one week. The first sowings were made on March 1, 1924, and March 3, 1925, and the last on May 6, 1924, and May 4, 1925.

The soil temperature, taken at the time of sowing, was determined by means of a soil thermometer. This method is open to considerable error because sudden changes in temperature are not recorded and therefore the mean temperature for the germination period is not determined. The periodic readings obtained, however, are indicative of the general trend.

At each sowing, samples of soil were collected at the depth of sowing and their moisture contents determined. These data are given in terms of the percentage of moisture-holding capacity of the soil. The results secured in both years are given in table 1.

The spring of 1924 was late and wet at Manhattan, while that of 1925 was early and dry. These conditions are reflected in the low soil temperatures and high soil moistures recorded for 1924 and the high soil temperatures and lower soil moistures recorded in 1925. The percentages of smut in all oat-smut experiments were higher in 1925 than in the preceding year. In 1924 relatively low smut percentages were obtained in sowings made

TABLE 1.—*Effect of soil moisture and temperature on smut infection in oats, Manhattan, Kansas, 1924 and 1925*

Date of sowing	Soil temperature in degrees F.	Soil moisture per cent	Per cent smutted heads when seed was											
			Inoculated						Uninoculated					
			Hull-less Ks. 5201	Aurora Ks. 5206	Richland Ks. 5209	Burt Ks. 6004	Burt Ks. 6090	Kanota Ks. 5179	Hull-less Ks. 5201	Aurora Ks. 5206	Richland Ks. 5209	Burt Ks. 6004	Burt Ks. 6090	Kanota Ks. 5179
1924														
Mar. 1	38.0	30.9	1.9	2.0	0.4	0.0	0.3	0.8	1.4	6.0	0.0	0.0	0.3	0.0
10	34.0	36.9	0.0	4.6	0.0	1.0	0.0	0.2	0.0	1.9	0.0	0.4	0.3	0.2
15	35.0	33.2	16.3	3.9	0.0	0.0	0.0	0.3	0.7	2.0	0.0	0.4	0.0	0.0
24	38.0	38.8	63.8	17.6	2.7	7.8	3.1	2.0	2.3	9.8	1.8	8.7	0.3	0.3
Apr. 2	44.0	33.5	71.5	14.4	3.8	6.6	3.8	2.9	1.2	14.0	1.2	1.2	0.7	0.3
8	63.0	22.7	73.3	16.8	4.8	12.3	4.1	7.1	3.8	12.4	0.5	3.4	0.6	1.5
15	62.0	20.1	74.4	11.8	2.3	7.7	2.1	2.1	2.0	8.9	0.0	0.0	1.3	3.7
22	66.0	15.6	38.3	23.9	0.3	3.8	1.5	2.3	1.7	8.9	0.0	0.0	0.9	0.6
30	57.0	33.2	28.3	10.4	0.0	0.6	0.2	1.2	0.0	15.2	0.0	0.0	0.0	0.4
May 6	70.0	31.7	16.7	9.1	0.0	1.3	0.4	0.0	5.0	12.0	0.0	0.0	0.4	0.0
1925														
Mar. 3	41.5	20.1	27.1	14.9	4.1	15.0	1.6	0.3	0.5	3.4	1.1	1.2	2.4	0.0
11	43.5	20.4	64.7	21.3	7.0	21.2	2.3	0.0	5.1	8.5	3.9	3.3	0.7	0.0
16	40.5	23.6	92.4	34.6	12.7	43.7	5.5	0.6	3.6	9.8	14.6	10.5	0.8	0.4
23	56.0	20.4	94.8	37.0	20.9	47.3	2.7	0.6	16.2	12.2	14.6	10.3	1.2	0.3
30	50.0	17.3	87.7	29.1	16.5	32.1	6.2	1.0	6.9	20.9	14.5	5.7	2.8	0.5
Apr. 6	47.0	31.5	71.6	35.5	18.6	40.4	4.7	1.5	13.7	4.1	16.1	23.3	2.5	0.0
13	61.5	20.9	76.9	69.0	30.0	40.4	8.4	4.8	37.3	26.0	15.0	10.8	5.5	2.0
20	62.0	20.9	85.6	73.5	17.6	25.9	8.7	2.2	14.5	32.6	16.1	12.2	5.8	0.0
27	60.0	20.5	61.7	17.6	11.4	13.4	2.2	0.0	2.8	2.3	8.8	5.8	2.7	0.0
May 4	59.0	18.1	33.3	0.0	3.2	0.0	0.0	0.0	4.1	0.0	0.0	0.0	0.0	0.0

while the soil temperature was below 38 degrees F. The highest infections secured from inoculated seed that year were at temperatures of 62, 63 and 66° F. Highest infections were secured at soil moistures of 15.6, 20.1 and 22.7 per cent of the moisture-holding capacity of the soil.

In 1925 the highest percentages of infection were obtained at soil temperatures of 56, 61.5 and 62° F. It will be noted that the soil temperature was higher on March 3, 1925, than on March 24, 1924, and that all the early sowings in 1925 showed more smut than in 1924. The soil-moisture percentages did not fluctuate so widely in 1925 as in 1924. Sufficient data to determine the specific effect of varying soil moistures are not available, but the two years' results indicate that infection takes place most readily at low soil moistures.

The above discussion is based on the results secured from the use of inoculated seed. The fluctuations in the smut percentages where uninoculated seed was used are so large that a lack of uniformity of distribution of the smut spores on the seed is indicated.

EFFECT OF DEHULLING OF OATS ON SMUT INFECTION

Attention already has been directed to the difficulty of obtaining high smut percentages in hulled varieties of oats and the ease of securing high infection in hull-less varieties. Gaines (2), Gaines and Schafer (3), and Stanton, Stephens, and Gaines (6) have shown that much higher smut percentages can be obtained by removing the hulls from the oat kernels. Tisdale (7) and Tisdale and Tapke (8) proved that both loose- and covered-smut infection in barley could be increased by the removal of the glumes before inoculation. Experiments conducted at Manhattan, Kansas, in 1924 and 1925 confirmed these results for oats.

A quantity of seed of each of five varieties of oats was dehulled and half of it inoculated. Half of a hulled sample was also inoculated, the same amount of smut being used in each case. An inoculated and uninoculated row from both hulled and dehulled lots of seed were sown on each of two dates.

The varieties of oats chosen for this experiment consisted of one susceptible, two moderately susceptible, and three resistant varieties. One resistant variety was a loose-palea type of Kanota in which the caryopsis is only partly covered by the glumes, the tip being exposed. This is equivalent to the glumes being loosened, but not removed, from the seed. The data secured in this experiment are given in table 2.

In this experiment also the smut percentages were much higher in 1925 than in 1924. In every case but one there was a noticeable increase in smut where the seed was dehulled and inoculated. A slight decrease occurred in the dehulled Kanota in 1925. There was a large increase in smut in

TABLE 2.—*Effect of dehulling on smut infection of six varieties of oats. Manhattan, Kansas, 1924–1925*

Variety and number	Previous reaction to smut	Average per cent of smutted heads							
		Seed inoculated				Seed not inoculated			
		1924		1925		1924		1925	
		Hulled	Dehulled	Hulled	Dehulled	Hulled	Dehulled	Hulled	Dehulled
Aurora Ks. 5206	Susceptible	14.1	49.2	30.6	67.5	12.2	8.1	14.6	2.7
Richland Ks. 5209	Moderately susceptible	4.3	51.7	27.8	49.0	1.4	0.9	16.5	1.3
Burt Ks. 6004	Moderately susceptible	10.1	75.9	48.2	84.9	2.0	0.0	16.8	2.4
Burt Ks. 6090	Resistant	2.1	18.3	4.0	27.4	0.8	0.2	3.3	0.0
Kanota Ks. 5179	Resistant	1.9	6.6	2.1	1.8	2.4	0.9	1.8	0.0
Loose palea Kanota Ks. 5179 sel.	Resistant	0.0	.....	2.3	.....	0.0	.....	0.0	.....

Aurora, Richland, the susceptible selection of Burt, and the resistant selection of Burt where the seed was dehulled and inoculated with smut before sowing. The increase was not so large in the resistant Burt as in the three susceptible varieties, but was much larger than that found in the two resistant strains of Kanota.

These data indicate that some varieties of oats, such as Burt Ks. 6090, which are usually considered as smut resistant, may merely be escaping infection through the protective qualities of their glumes. Others, such as Kanota, apparently have heritable protoplasmic resistance to smut, although their glumes also provide considerable protection. While dehulling the grains of susceptible varieties before inoculation increased the amount of infection, it still did not seem possible to procure 100 per cent infection, nor were the percentages obtained as high as those usually secured in hull-less varieties. It seems likely that hull-less varieties are heritably more susceptible than the hulled varieties used in these studies.

When the seed was not inoculated before sowing, there was a smaller amount of smut, in every case, in the rows from dehulled seed than in those from hulled seed. This probably is due to the fact that most of the spores are carried on or in the glumes and therefore are removed with them.

SUMMARY

1. Weekly sowings of six varieties of oats made during the seasons of 1924 and 1925 show that low smut infection takes place in very early and very late sowings.

2. High smut infection seems contingent on high temperature and low moisture content of the soil. Soil temperatures of 62° to 66° F. seemed to be most favorable for infection. Highest infections were obtained with the soil moisture below 30 per cent of the water-holding capacity of the soil.

3. Removal of the glumes from oats caused a large increase in the amount of smut infection. This increase was largest in susceptible and moderately susceptible varieties and much smaller in resistant varieties.

4. Comparison of the reaction of resistant Burt and Kanota when the glumes are removed indicates that the former derives part of its freedom from smut from the mechanical protection of its glumes, while the latter has a larger amount of heritable protoplasmic resistance. Thus it seems that some varieties of oats escape infection through the protection of their glumes, while others have protoplasmic resistance.

5. One hundred per cent infection was not obtained even with dehulled seed regardless of the heavy inoculation. This may be due to resistant individual plants in the hulled varieties used.

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BOOK REVIEW

Syokubutu-Byôrigaku, a Text-book on Plant Pathology is Romanized Japanese. By N. SUEMATU. Small octavo. 274 pp., 33 plates partly colored, and 153 figs. in text. Price $2.60, postage incl. Published by Nippon-no-Rômazi-Sya, Hongô Komagome Akebonotyô 11, Tokyo, Japan.

The book is divided into a general and a special part. The former, which occupies almost two-thirds of the book, contains six chapters entitled: Plant Diseases in General, Bacteria, Fungi, Parasitism, Immunity, and Control of Diseases. The special part consists of six chapters which are concerned with the diseases of the rice-plant, wheat, barley, fruits, legumes, various other cultivated plants (like mulberry, tea, tobacco, etc.), bamboos, trees, ornamental flowers, etc.

The book is clearly and concisely written. It is richly illustrated. Some of the figures necessarily are copied from foreign sources; many of them, however, are original. The latter are photographs and drawings made from nature by the author himself and his friends—the results of their laborious work on the pathology of Japanese plants. Although the text itself, written in Japanese, may not be available to many American and European pathologists, these figures will be of much interest to them, especially as their explanation often contains the Latin names of the causal organisms.

—S. IKENO, Professor of Botany, Tokyo Imperial University, Japan.

ABSTRACTS OF PAPERS PRESENTED AT THE EIGHTEENTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY, PHILADELPHIA, PA., DECEMBER 27, 1926, TO JANUARY 1, 1927

Yellowing of alfalfa caused by leafhoppers. FRED R. JONES and A. A. GRANOVSKY.

In late June and early July, 1926, alfalfa "yellows" became unusually conspicuous locally in Wisconsin on the second crop of alfalfa. Several species of leafhoppers, especially *Empoasca fabae* (Harris) and *Deltocephalus inimicus* (Say), were abundant on the yellow plants. Since *Empoasca fabae* has been shown to initiate hopperburn of potato and apple, infestation experiments were performed to determine whether these insects were also responsible for alfalfa "yellows." Healthy alfalfa plants in cages in the greenhouse were infested with leafhoppers from the yellow alfalfa in the field. Insect-proof cages were constructed over several varieties of alfalfa in the field. The alfalfa in the cages was cut back, the cages were fumigated, and when new growth started half of the cages were infested with leafhoppers. Both in the greenhouse and in the field the infested alfalfa showed yellowing and dwarfing indistinguishable from that in surrounding fields; while in the uninfested cages alfalfa was vigorous and green. In autumn, the alfalfa crowns in the infested cages were conspicuously smaller than those in the uninfested cages, and many small seedlings of Grimm alfalfa were dead. These experiments have demonstrated beyond doubt that *Empoasca fabae* is responsible for alfalfa "yellows." The Wisconsin Experiment Station is continuing the study of this disease. (Cooperative investigations by the Office of Vegetable and Forage Diseases, Bureau of Plant Industry, U. S. Department of Agriculture and the Wisconsin Agricultural Experiment Station.)

Sugar beet curly-top virus, the cause of western yellow tomato blight. M. B. MCKAY and T. P. DYKSTRA.

The cause of western yellow tomato blight has remained a mystery for over a quarter of a century. Very striking circumstantial evidence in many fields during the past summer indicates that this disease is caused by the virus of sugar beet curly-top. Carsner reported tomato as susceptible to curly-top, but because only young plants were used and these died early no symptoms identical with western yellow blight were noted. Richards, of Utah, and others have observed the unusual correlation in the prevalence of sugar beet curly-top and western yellow blight of tomatoes in different years.

Recently the writers have induced healthy tomato plants to develop typical symptoms of western yellow blight under greenhouse conditions. Viruliferous leafhoppers, *Eutettix tenella*, from curly-top beets were placed on the healthy tomato plants. After an incubation period of two to three weeks, symptoms developed comparable to those so frequently observed in the field. These were general yellowing of the foliage, a rolling of the leaves, a purpling of the veins and a marked stunting of the plant. Some of the same leafhoppers which transmitted the disease to tomatoes also carried curly-top to sugar beets. The untreated controls have all remained healthy. (Cooperative investigation between the Oregon Agricultural Experiment Station and the Bureau of Plant Industry, Office of Vegetable and Forage Diseases.)

The control of plant disease through seed certification—aided by test gardens and field crop inspections. H. L. BOLLEY.

This paper is based upon the author's attempts to control certain diseases, particularly of potatoes, flax, and cereals, through breeding and selection under intensified conditions of disease infection. As early as 1896 special gardens for the accumulation and intensification of pathogens in soil and crop were prepared for the purpose of emphasizing "the survival of the fittest" through elimination of the non-resistant individuals. Through this method the author has introduced several strains of disease-resistant wheats and flax, capable of producing good yields under the most favorable conditions for infection. The work of other plant breeders also, including plant pathologists, agronomists, and practical plant selectionists, has progressed rapidly during late years, but the results on farms and in gardens are not what they should be, because it is impossible for the average farmer to keep the lines pure and disease-free.

The writer advocates protection of the work of plant breeding and crop improvement through seed certification, checked by the establishment of carefully planned gardens in which test plantings are made of diseased and disease-free pure lines for careful study preparatory either to greater distribution, or to certification, of those already widely distributed.

The effect of leaf rust, Puccinia triticina, on the seed production of wheat. E. B. MAINS.

Leaf rust often has been considered as causing little or no loss in production. By a comparison of a number of series of rusted plants with rust-free plants in the greenhouse from 1922 to 1925 it has been found that under some conditions there is a considerable reduction in the seed developed by rusted plants. The extent of the reduction depends on the severity of the infection, the infection period, and varietal susceptibility. When susceptible varieties are heavily infected from the seedling stage to maturity, little or no seed is produced. Severe infection from the beginning of heading to maturity has produced 15 to 25 per cent reduction in seed formation. It was found that the upper and lower spikelets in the heads of rusted plants usually failed to develop seed. The middle spikelets produced fewer seeds due to the failure of the development of the central flowers. Blossoming starts in the outer flowers of the spikelets and the middle spikelets of the head, progressing inwardly in the spikelet and up and down the head. While the first flowers to blossom in rusted plants are able to receive sufficient material for the development of seed, the later blossoms are starved and fail to develop seed. (Cooperative investigations by Purdue University Agricultural Experiment Station and Bureau of Plant Industry, U. S. Department of Agriculture.)

Susceptibility of wheat varieties and hybrids to wheat scab in Minnesota. J. J. CHRISTENSEN and E. C. STAKMAN.

During the past six years more than 250 varieties of *Triticum* spp., and a considerable number of selections from crosses, were subjected to an artificial epidemic of wheat scab at University Farm, St. Paul, Minnesota. The amount of seedling blight and head blight in the same variety in different years varied with the date of sowing and with temperature and humidity at flowering time. There also was some circumstantial evidence that different parasitic strains of the pathogene may have been present in different years. Durums as a class were more susceptible than common wheats, although there were susceptible and resistant varieties in both groups. No varieties were immune. The following were the most susceptible vulgare wheats: Marquis, C. I. 3641; Kitchner, C. I. 4800, and Red Bobs, C. I. 6255. The following were resistant: Glyndon Fife,

Minn. 163; Haynes Bluestem, Minn. 169; and Prelude, C. I. 4323. Preston, Minn. 924, was resistant for four years, but in 1925 it was heavily infected. Most of the durum varieties were susceptible. Monad, C. I. 3320, and Acme, C. I. 5284, were especially susceptible; while Arnautka, C. I. 1494, and Mindum, Minn. 470, were somewhat resistant. A few durum varieties have always been almost free from infection. Most of the hybrids tested were intermediate in their reaction to scab. Some pure lines obtained from crosses between Marquis × Preston and Marquis × Haynes Bluestem were as resistant as the resistant parents. Some lines of Marquis × Preston appeared to be more resistant than either parent. (Cooperative investigation between the Section of Plant Pathology and the Section of Plant Breeding, Department of Agriculture, University of Minnesota.)

Certain factors influencing the development of the mosaic disease in winter wheat. ROBERT W. WEBB.

Many varieties of winter wheat, notably Currell, show only the mottling phase of mosaic, while only a few varieties, notably Harvest Queen, exhibit both the mottling and rosette phases. Experiments with these two varieties grown continuously in infested soil or transplanted from or to infested soil have shown: (1) that the infection period is confined to the seedling stage; (2) that seedlings transplanted to infested soil appear most susceptible to rosette when four weeks old and less susceptible when younger or older; (3) that under very favorable environmental conditions an exposure to infested soil of one week from date of seeding is sufficient to cause a high percentage of diseased plants, and that longer periods, within limits, give increased percentages; (4) that the disease develops only at relatively low constant or low average soil temperatures; and (5) that the disease development is favored by relatively high constant soil moistures. (Investigations conducted by the Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, in cooperation with the Wisconsin Agricultural Experiment Station.)

The corn mosaic of Hawaii distinct from sugar cane mosaic. L. O. KUNKEL.

Experiments with the corn leafhopper, *Peregrinus maidis* (Ashm.), obtained from North Carolina show that this insect is unable to transmit the virus of the sugar cane mosaic of the United States to corn. A careful comparison made by Mr. Fred Muir, of the Experiment Station of the Hawaiian Sugar Planters' Association, indicates that this insect is identical with the *Peregrinus maidis* of the Hawaiian Islands which transmits the virus of the mosaic disease of corn studied by the writer in Hawaii. This suggests that the destructive mosaic of corn prevalent in Hawaii is distinct from sugar cane mosaic and from the mosaic of corn occurring in Louisiana and other Southern States.

The fungous flora of the nodes of corn. C. L. PORTER.

Isolations from more than 2,000 nodes of corn stalks, collected during a field survey extending over 20 different States during the summer of 1926, showed no specific organism associated with the decomposition of nodal tissues. No correlation between specific organisms and the iron content of the nodes was possible, although as a rule the greater iron content was present in the more highly decomposed tissues. The most prevalent fungi were species of *Fusarium*, *Alternaria*, and *Helminthosporium*. Nine morphologically distinct types of bacteria were isolated. None of these organisms was consistently associated with any type of nodal breakdown. Sound, clean nodes were sterile in many cases.

Smut resistance in corn. MARION A. GRIFFITHS.

Strains of corn, highly resistant to smut under field conditions, were found to be very susceptible to infection when conidial suspensions were injected into meristematic and very young, rapidly growing tissue. The young parts of plants of any age were susceptible. Pouring the inoculum into the top of the plant resulted in a relatively low percentage of infection as compared with the high percentage obtained when the inoculum was injected into the apical bud. Similar results were obtained under field and greenhouse conditions. Resistance of these strains of corn in the field appears due merely to the fact that inoculum does not reach the young growing tissue.

Strains of Ustilago nuda and certain host relationships. W. H. TISDALE and MARION A. GRIFFITHS.

Investigations of the loose smut of barley conducted on Arlington Experiment Farm, Rosslyn, Virginia, show that variants exist within the species *Ustilago nuda* (Jens.) Kell. and Sw. Loose smut collected there in 1923 from Tennessee Winter barley contained two strains of the fungus. Spores from this collection smutted the varieties Han River and Alaska. Spores from Han River smutted Hannchen 100 per cent; while spores from Alaska, which produced 100 per cent smut in Orel, produced none in Hannchen. In no case did smut spores from the Alaska variety smut Hannchen, even though the fungus was grown in other varieties before Hannchen was inoculated. Spores of smut from Hannchen which came through Han River from Tennessee Winter produced 60 per cent of smut in Alaska. Of 32 collections of smut from various sources, 26 produced smut in Tennessee Winter, while only 9 produced smut in Hannchen. Often where smut did not occur in mature plants, infection took place, as evidenced by poor germination, seedling injury, and smutting of secondary shoots from stubble. The amount of seedling injury is not closely correlated with smut percentages.

Cercosporella leafspot of Chinese cabbage. W. H. DAVIS.

Leaves of Chinese cabbage (*Brassica pekinensis* Rupr.) bearing paper-white lesions have been under observation for three years in the vegetable gardens at the Massachusetts Agricultural College. The disease was most severe in autumn. Some plants were killed while others were only lightly infected. Circular lesions with paper-white centers crossed by dark-brown veinlets proved unmistakable symptoms of the disease.

An organism, for which the name *Cercosporella* (*Cercospora*) *albo-maculans* E. and Ev. is suggested, was found to cause this leafspot.

There are two types of mycelium; hyphae in living tissues are 2μ, in dead tissues 5 μ in diameter.

Sclerotia-like bodies giving rise to hyaline conidiophores measuring 3 x 10–13 μ were located in the lesions directly beneath the dead epidermal cells. The conidia are hyaline, elongate-cylindrical, curved, 0–5 septate, 2.5 x 56 μ. They germinate with difficulty. The following plants were inoculated with conidia from Chinese cabbage: parsnips, beets, carrots, celery, common cabbage and Chinese cabbage. All except Chinese cabbage remained healthy.

The Fusarium wilt of sweet potatoes on infested soils. R. F. POOLE.

The Fusaria which causes sweet potato wilt may be abundant in a field, but seem not to be uniformly distributed through the soil, since some plants remain healthy in infested fields throughout the season, even though many plants are killed in July and August. This was further shown when the percentage of healthy plants was increased

by using two or more plants in a hill. The plants that showed no infection, when harvested in October, were not resistant to the disease, as was shown later by testing them on infested soil. The disease did not spread from one plant to another even when heavily inoculated plants of the susceptible Porto Rico and Yellow Jersey varieties, which became diseased and died, were set one to eight inches from healthy plants of the same varieties. When the soil was artificially inoculated with a heavy suspension of spores the infection was not so severe as that resulting from immersing abscissed and cleanly removed stems in the same inoculum. A large percentage of the plants manifested symptoms of the disease in less than 14 days. Some died within 21 days, while others were not killed until late in October. Likewise, a small percentage of plants inoculated in July showed no symptoms of disease until late September.

Radish black-root caused by Aphanomyces raphani n. sp. JAMES B. KENDRICK.

Cultural and inoculation studies have proved that the causal organism of radish black-root is an undescribed species of *Aphanomyces* for which the name *A. raphani* n. sp. is proposed. *Pythium aphanidermatum* (Edson) Fitz. has not been found associated with the disease, and neither this organism nor *Aphanomyces cuteiches* Drechsler have proved pathogenic to radishes in inoculation tests. *A. raphani* resembles *A. cuteiches* in its oogonia and oospores, but differs from both *A. cuteiches* and *A. laevis* de Bary in that the tapering portions of its zoosporangia from which the zoospores escape show spiral twisting, and in that the diameters of its vegetative hyphae are much greater. The mycelium is intercellular, and the diseased tissues are killed but remain firm unless invaded by rot-producing organisms. Saprophytic bacteria occur very commonly in the diseased tissues. The optimum temperature for the fungus is 23 to 27° C. The disease is more severe on the long than on the round type of radishes owing to the distribution of the infection courts which are the natural wounds made by the emergence of secondary roots from the primary root.

The development of nailhead spot of tomatoes during transit. G. B. RAMSEY and ALICE A. BAILEY.

For many years the disease of tomatoes known as Nailhead Spot has caused considerable damage to the Florida crop in the field as well as during transit and marketing. Lack of data regarding this latter phase of the disease led to a study, during the past two seasons, of the rate of development of the spots present at shipping time and of the development of new spots during transit. Mature green tomatoes were selected at the packing houses and inspected individually. The diameter, in millimeters, of all spots was marked in India ink at the side of each lesion before the fruit was wrapped and packed. The marked crates were shipped to Chicago and a record made of all spots on each fruit at the time of arrival.

The data are summarized in table 1.

TABLE 1.—*The development of nailhead spots of tomatoes during transit*

Diameter of spots, in mm., at shipping point	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
Average increase in diameter after 6¼ days in transit	1.41	1.22	1.19	1.11	.87	.66	.58	.52	.27	.33	.21

(Contribution from the Research Laboratory on Market Diseases of Fruits and Vegetables, United States Department of Agriculture, Bureau of Plant Industry; the Florida Agricultural Experiment Station, and the Department of Botany, University of Chicago, cooperating.)

Effect of seed treatment on growth, yield, and disease control in vegetable crops. E. E. CLAYTON.

Seed treatment experiments conducted over a three-year period, both in the greenhouse and in the field, have shown disease control effects of two sorts: (1) Seed-borne parasites such as *Phoma lingam* and *Pseudomonas campestris* have been destroyed. (2) Seedlings have been protected during the early stages of growth from attack by soil inhabiting parasites. Under field conditions effects of the first kind have been more frequent.

Stimulation of early plant growth may be readily produced by treating the seed with a variety of chemicals, such as manganese sulfate, arsenic iodide and arsenate of lead. The cucumber has proved very responsive, and striking results have been secured in greenhouse tests. Suitably replicated field tests, however, showed no significant yield differences. In other experiments genuine stimulation effects were apparent. These resulted most frequntly from hot seed treatment, and the yields in these cases have been increased as much as 50 per cent. However, it has not yet been found possible to produce these effects consistently.

Retardation of plant growth, aside from reduction in stand, may result from seed treatment. Potatoes soaked in mercuric chloride shortly before planting occasionally showed retarded sprouting and reduced yield. Lima bean seed dusted with a mercury chlorophenolate seed disinfectant regularly produced smaller vines and yields than untreated seed.

The relation of Mycosphaerella pinodes to Ascochyta blight of peas. LEON K. JONES.

Two closely associated species of *Ascochyta*, capable of producing distinct diseases of pea plants, have been found carried frequently in the seed. Pycnospore measurements of the two species are similar and fall within the range given for *Ascochyta pisi* Lib. One organism produces its ascigerous stage on culture media and on infected host parts. Mature perithecia have been found on pea plants 25 days after inoculation and on culture media 15 days after inoculation. Morphological characters of this ascigerous stage are similar to those described for *Mycosphaerella pinodes* (Berk. and Blox.) Stone, but host and cultural relations of the organism differ markedly from those of *A. pisi*. This organism produces a serious brown to black basal stem rot of peas, and indefinite, uniformly purplish brown foliage lesions. The other organism produces host reactions as described for *A. pisi*, but the writer has been unable to find the ascigerous stage of this organism. From a study of the literature and of herbarium specimens at Cornell University, prepared by R. E. Stone, and from inoculation experiments, it is evident that these two organisms have been confused and that *M. pinodes* is not the ascigerous stage of *A. pisi*.

Leaf temperature in relation to tip burn of lettuce. E. L. LECLERG.

The leaf temperature measurements of lettuce indicate no relation between this factor and tip burning. Temperature measurements were made by means of Leeds and Northrup galvanometer reading in eighths of a degree. The lettuce used was grown under glass at known temperature and humidity.

On normal plants in the sun, the top of the leaf was found to be 2° C. and the bottom 2.1° C. cooler than the surrounding air. In the shade, the top of the leaves was

1.6° C. and the bottom 1.3° C. warmer than the surrounding air. In general the top and bottom of the normal leaves varied but a few tenths of a degree—the upper side in both shade and sun being 0.1° C. to 0.3° C. warmer. The edge of normal leaves was found to be 0.7° to 0.8° C. warmer than the base or main body of the leaf.

Hourly temperature readings, day and night, on lettuce leaves during the process of tip burning showed them to be approximately 5° C. cooler than the surrounding temperature.

Studies of apple scab and cherry leaf spot infection under controlled conditions. G. W. KEITT.

Further studies of apple-scab infection with the same apparatus and method have confirmed and extended the results reported last year (PHYTOPATH. **16**: 77). The results then reported on the relations of temperature to infection have not been significantly modified. The minimal numbers of hours of continuous wetting which have yielded leaf infection by ascospores at the temperatures stated are as follows: 6° C., 15; 9°, 11; 15°, 7; 20°, 4; 24°, 6; and 26°, 10. Many ascospores induced infection without developing a well differentiated germ tube, the spore itself functioning as an appressorium from which an infection hypha penetrated directly into the cuticle.

Similar studies of leaf infection of *Prunus cerasus* L. by *Coccomyces hiemalis* Higgins were initiated. Conidia from cultures were suspended in water and applied by atomizers. The initial stages of infection occurred at constant temperatures ranging from 12–13° C. to 28° C. The maximal and minimal temperatures for initiation of infection are not yet clearly established. Lesions developed on inoculated plants incubated at controlled temperatures ranging from 8–11° C. to 28° C. Minimal incubation periods varied from 6 days at 24° C. to 11 days at 28° C. The minimal period of wetting observed to permit infection was five hours at 20° C.

A possible reorientation of aims and methods for apple scab control. G. W. KEITT and E. E. WILSON.

It has been shown by Keitt and Jones that abundant and timely ascosporic inoculum is of primary importance in epidemiology and control of apple scab; and that current fungicidal programs, being adapted primarily to protect fruit, frequently fail to prevent recurrent development of such inoculum. Reduction of ascosporic inoculum may be sought: (1) by preventing foliage infection, (2) by treating living leaves after infection, or (3) by treatment or disposal of dead leaves. Hitherto, considerable attention has been given to the first and third methods, but little to the second. For three years the writers have sought a fungicide which, applied after harvest but before leaf-fall, would economically prevent or limit the development of ascospores without serious host injury. About 75 small-scale trials have been made, chiefly with the following materials: a variety of copper, sulphur, mercury, and arsenic preparations and fluosilicates. These experiments are as yet incomplete and the results inconclusive. However, numerous preparations have appeared to inhibit or prevent production of ascospores. Consequently the post-harvest season prior to leaf-fall appears to cover a potentially vulnerable phase in the life-history of the fungus, and much promise for improvement in the control program seems to lie in sharply limiting the ascosporic inoculum.

Details in the life-history of the apple blotch fungus. EDWIN J. KOHL.

Spores germinated in water on slides adhere closely to the slide and can be washed off only with difficulty. They do not form appressoria on the slide. Spores germinated on leaves form appressoria.

The period of incubation is 20–24 days; on the leaf blade it is shorter than on the petiole. This was determined by placing one-year-old, healthy, potted, Duchess apple trees under a diseased tree, and removing immediately to a safe place after each rain. In 1925, infection occurred at La Fayette, Indiana, during each of the five rain periods between 5 and 8 weeks after petal-fall (May 19). In 1926, infection occurred at La Fayette, Indiana, during 10 out of 24 rain periods between 5 days and 8 weeks after petal-fall (May 18). At Mitchell, Indiana, in 1926, there were 14 rain periods during the 9 weeks subsequent to petal-fall (May 10) and infection occurred only during the 4th and 7th of these periods at 3 and 4½ weeks after petal-fall, respectively.

The mycelium of the fungus has been found to be intercellular and confined to the collenchyma layer. At a considerable distance below the visible margin of the petiole lesion it was traced in this layer into the abscission layer.

Apple blotch canker eradication. MAX W. GARDNER.

The effectiveness of blotch canker eradication in two young apple orchards of the Oldenburg variety at Vincennes, Indiana, has been demonstrated by the freedom of the fruit from infection in blocks of trees left unprotected by the blotch sprays during 1925 and 1926. One of these orchards was set out in 1917, the other in 1918. The eradication campaign was begun in 1922 and consisted in shaving off or pruning out the old cankers and spraying to prevent the formation of new cankers.

Mosaic of red and black cultivated raspberries. W. H. RANKIN.

The degree of control obtained by the use of mosaic-free planting-stock and roguing is extremely variable in New York. Causes of this variation apparently include such factors as: the relative abundance of the principal insect vector, *Amphorophora rubi* (Kaltenbach) Mason; variations in the frequency and intensity of aphid dispersal; and the klendusity of the variety in question. Klendusity (escaping inoculation) and susceptibility are fixed factors in the different varieties and are not correlated. Mosaic is believed to spread almost entirely by the mechanical dispersal of the vector by wind, rain and cultivation operations. A biological relation between the aphid and virus is indicated by the fact that infection in red and black raspberries is initiated only by aphids in the first and second instar.

Mosaic in red and black raspberries has been proved identical and is the most important virus disease of both sorts in New York. The symptoms on black raspberries seem to vary from the initial and progressive necrotic effects to conditions resembling, if not identical with, other previously described virus diseases.

Strains of Pseudomonas tumefaciens. M. K. PATEL.

In isolation studies of *Pseudomonas tumefaciens* from overgrowths on nursery stock and from nursery soils, pathogenic and non-pathogenic strains have been obtained. Fifteen non-pathogenic strains have been recovered in isolations from 200 three-year-old grafted apple trees. Ten of these resemble the pathogenic strain of *Pseudomonas tumefaciens* in morphological characters and in 32 different physiological reactions. The remaining five reacted like the pathogenic strain, except in one characteristic. Of these, four liquefied gelatin and one reduced nitrates. Repeated applications of these strains failed to cause infection with them on tomatoes and castor beans, although trials with the pathogenic strain were always successful. The non-pathogenic strains have been found most abundant in the apple nursery row. They are readily cultured in dilutions on bile agar. The pathogenic strain isolated from soil has retained its pathogenicity for

10 months. The presence of the non-pathogenic strains in overgrowths is probably explained by the presence of the non-pathogenic strain in the soil. Pathogenic strains that have been maintained in culture for two years are still virulent.

Pleospora rot of lemons and apples. D. H. ROSE and L. F. BUTLER.

A species of *Pleospora*, probably *P. herbarum* var. *citrorum*, has been isolated from two lots of decayed lemons from California found on the market. What appears to be the same fungus has been isolated twelve times from apples shipped from Washington, Oregon, and California. The record on lemons confirms an earlier report by Fawcett, although the rot we found occurred on the side of the fruit rather than at the stem end. The record on apples is new as far as we can discover.

Cross inoculations prove that cultures from both lemons and apples are pathogenic to both kinds of fruit and suggest that the fungus making the initial attack is the same in both cases.

On both lemons and apples the rot develops slowly; affected tissues are brown to almost black, firm and rather dry. In lemons the attack is confined usually to the peel; in apples it may penetrate to the core.

The fungus produces both ascospores and conidia (*Macrosporium*) in culture. Single-spore cultures from these have in every case reproduced both kinds of spores. This seems to prove that the conidial stage of this species of *Pleospora* is a *Macrosporium*.

The effect of spraying with fungicides on the keeping quality of Florida citrus fruits. HARRY R. FULTON and JOHN J. BOWMAN.

Florida citrus fruits are liable to losses in marketing from two types of blue-mold rot caused by *Penicillium digitatum* and by *P. italicum*, and also from two types of stem-end rot caused by *Phomopsis citri* (*Diaporthe citri* Wolf) and by *Diplodia natalensis*. Extensive experiments for six seasons show that a single application made April 15 and May 5 of 3-3-50 Bordeaux mixture plus 1 per cent oil in the form of an emulsion will reduce total rot about one-third during a prolonged marketing period. The effect is mainly on the more common Phomopsis type of stem-end rot, which is reduced more than one-half. The Diplodia stem-end rot is reduced only about one-fifth by the one application. Penicillium rots are not materially affected. This application is the one used for controlling the melanose blemish caused by the same species of *Phomopsis* and can be expected to give about 90 per cent melanose control. Two spray applications in the spring control rot slightly better in the marketed fruit than one application, owing mainly to increased effectiveness against the Diplodia rot. Mid-summer and fall applications are relatively ineffective. The oil emulsion is necessary in the Bordeaux mixture and also must be used alone a few weeks later to check increase of scale insects following the destructive action of the copper fungicide on the entomogenous fungi which keep these pests in check.

Watermelon wilt infection studies. D. R. PORTER.

In 4,700 isolations from watermelon vines infected with *Fusarium niveum* Smith, this fungus has been obtained from stems, leaves, petioles, pedicels, fruit, primary, secondary, and tertiary roots and probably seeds.

This *Fusarium* causes cankers on the primary and secondary roots at any point below the surface of the soil. They are, however, more prevalent from 6 inches to 2 feet down, and appear in early stages as water-logged, light yellow lesions, varying in

length from one-half to several centimeters. Vascular invasion follows the development of lesions, which, in early stages, is local rather than general. The organism may then spread very rapidly throughout the root system. Maximum wilting occurred in 1926 after the melons had set.

Supposedly immune citron vines have yielded *Fusarium niveum* pathogenic to watermelon seedlings. Seemingly healthy watermelon plants, on land that had never before produced watermelons, likewise yielded the fungus. The fungus appears to remain alive in soil where watermelons have not been grown for at least 16 years.

Bacterial halo spot of kudzu. FLORENCE HEDGES.

Bacterial halo spot of kudzu is of particular interest because of the steadily increasing economic importance of kudzu in the south as a forage plant and a cover crop for pecans. The wide yellow halo surrounding the small brown spots is strikingly like that in tobacco wildfire. When the spots are close together, the halo is less evident or disappears altogether. Young lesions are angular and water-soaked. The disease has been reported by Clinton in Connecticut and Boyd in Georgia. In a survey of kudzu fields in Georgia and Florida, the writer found the disease in new fields planted with roots from a diseased stand, while other fields in the vicinity were free from infection.

From the lesions, the writer has isolated a polar-flagellate, non-spore-forming, aerobic, white organism pathogenic both to kudzu and lima bean. On beef agar it forms bluish white, somewhat opalescent, crenate colonies with internal cross-hatching; it liquefies gelatin, produces acid from glucose and saccharose in beef extract agar, but none from lactose; slow peptonization, but no acid or reduction of litmus, produced in litmus milk; no reduction of nitrates; blue-green fluorescence in Fermi and Uschinsky; nutrient gelatin greened, beef broth and beef agar slightly so; feeble diastasic action; steamed-potato cylinders grayed; cream colored growth on potato. The organism has been tentatively named *Bacterium pueriae.*

A mosaic resistant variety of cucumbers. O. H. ELMER.

A variety of cucumbers named "Chinese Long" obtained from Professor R. H. Porter, of Nanking, China, in tests during the past year has proved highly resistant to the cucumber mosaic disease. Porter stated concerning it that "Last year I did not observe any (mosaic) in this locality—(nor)—thus far this season." Chinese Long cucumber is a slicing type not suitable for pickling.

Mosaic inoculation tests conducted in the greenhouse, where 50 plants each of the varieties Chinese Long and White Spine were inoculated, have to date resulted in no infection in Chinese Long and approximately 100 per cent infection in White Spine. In a field plot consisting of five six-rod rows, aphids transferred from mosaic cantaloupe plants failed to induce infection.

Curly-top of squash. M. B. MCKAY and T. P. DYKSTRA.

In August of this year, a severe disease, never before observed on squash, was found in many places in Oregon, Washington and Idaho. Generally the plants appeared yellow and badly stunted, the leaves had yellow, upturned margins and were small, though in some varieties the margins turned down and the leaf blades were crinkled. Often the plants produced a new runner from the axil of each leaf on the main branches. Some tissues in the roots were noticeably discolored, being yellow to light brown in color. Plants affected early remained very small and developed a striking witches'-broom type of growth. The disease was observed on the following varieties or kinds of squash:

Boston Marrow, Green Hubbard, Summer Crookneck, Mammoth White Bush Scallop and Silver Skin. The general failure of squash in the Northwest this year was due largely to this disease.

Circumstantial evidence suggested that the disease was due to the virus of the sugar beet curly-top disease. The disease has been readily and repeatedly produced in the greenhouse by the use of beet curly-top viruliferous leafhoppers, *Eutettix tenella*, on healthy plants. Individual leafhoppers which induced curly-top on squash also caused curly-top on sugar beet. Untreated controls invariably remained healthy. (Cooperative investigation between the Oregon Agricultural Experiment Station and the Bureau of Plant Industry—Office of Vegetable and Forage Diseases.)

Commercial tobaccos and cured leaf as sources of tobacco mosaic. W. D. VALLEAU and E. M. JOHNSON.

Results of inoculation of a number of commercial brands of tobacco and air-cured leaf of different sources and ages indicate that these may be sources of the mosaic disease in tobacco. The disease has been produced by inoculations of tobacco from four brands of plug, three brands of cigarettes, and five brands of granulated smoking tobacco. Almost 100 per cent infection has been produced from air-cured leaf as old as five years, both in field and greenhouse tests. Field tests indicate that primary infection from the use of tobacco by workmen in the field can be reduced to less than one-half of one per cent (in one test to zero) by requiring the use of heat sterilized tobacco by the workmen while pulling plants from the bed and during transplanting in the field. Preliminary experiments indicate that the disease can be produced from dried tobacco as old as 18 to 30 years.

Correlation of virulence and acid agglutination of a smooth and a rough strain of Bacterium phaseoli sojense. C. G. SHARP.

A smooth and a rough strain, which have remained constant in culture, were isolated from a culture of *Bacterium phaseoli sojense*.

Smoothness apparently is correlated with greater virulence, and roughness with lesser virulence. When inoculated into leaves of soy beans by needle pricks, the smooth strain produced 62 per cent infection in 4 days; the rough, 39 per cent. Both strains produced 100 per cent infection in 8 to 10 days. The lesions produced by the smooth strain averaged 1.033 mm. in diameter (575 measurements). Those produced by the rough averaged 0.808 mm. (579 measurements). By passage through plants, the rough strain has been converted to the smooth.

Roughness and lesser virulence are correlated with greater agglutinability. The rough strain agglutinates spontaneously in distilled water. The smooth one does not. The rough strain agglutinates in distilled water plus acid or alkali through the wide range of pH 1.2 to 9.4 with low agglutination at about pH 5.5. The smooth one agglutinates only through the narrow range pH 2 to 3.

The organism of the smooth strain is very motile. The rough one is either very sluggish or non-motile.

These strains cannot be differentiated serologically (agglutination and precipitin tests).

The results of these investigations demonstrate concordance between phenomena in plants and those previously reported in animal pathology.

Correction of unproductive muck by the addition of copper. E. L. FELIX.

Certain more or less sharply defined areas of the muck soils in Western New York, involving approximately 400 acres, have been found unproductive, especially for lettuce

and onions. Plants grow normally for a time and then suddenly assume pronounced abnormalities which result in complete failures on severely affected soils. Experiments of the past three seasons show that the most prevalent type of unproductivity can be corrected by the addition of copper to the soil or plants. Applications of pulverized copper sulfate crystals at the rate of 100 to 200 pounds to the acre, prior to sowing, resulted in the production of normal crops. Painting the leaves of affected lettuce with a weak solution of copper sulfate caused the plants to outgrow the abnormalities. Dusting lettuce grown on unproductive muck with 20–80 copper-lime dust at the rate of 55 pounds to the acre likewise caused the plants to become healthy. Experiments indicate that copper is the beneficial element added and that it may be a vital factor in the growth of plants on such soils.

A theory to account for the bactericidal action of sodium silicofluoride and lack of injury to host tissues. H. W. ANDERSON.

A 1–200 solution of sodium silicofluoride used as a spray on peach trees has successfully controlled bacterial spot, caused by *Bacterium pruni*, without serious injury to the host tissues. According to the equation,

$$Na_2SiF_6 + 3\,H_2O \leftrightarrows 2\,NaF + 2\,H_2F_2 + H_2SiO_3,$$

hydrolysis would result in the formation of hydrofluoric acid, supposedly highly toxic to plant tissues. H-ion determinations of dilute solutions (1–100,000) show that complete hydrolysis and dissociation occur, but in more concentrated solutions (1–1,000) only partial dissociation occurs. When sodium silicofluoride solutions are sprayed on foliage the water evaporates, leaving the salt. When water is added, sodium silicofluoride should be present in the following conditions: (1) undissolved; (2) dissolved and not hydrolyzed; (3) dissolved and hydrolyzed but HF not dissociated; (4) dissolved and HF dissociated. The first three conditions probably are predominant and, while the amount of dissociated HF on the leaf at one time is not sufficient to cause injury, yet a 1–25,000 solution of sodium silicofluoride will kill *B. pruni* in 10 minutes. A 1–50,000 solution will kill over 99 per cent of them. Hydrofluoric and hydrochloric acids in proportionate strengths are equally toxic to *B. pruni*. Hard water used in mixing the sprays reduces the acidity of the sodium silicofluoride solution, but not enough to interfere with the efficacy of the sprays.

Fungicidal control of brown-patch of turf. JOHN MONTEITH, JR. and T. CARTER HARMON.

Mercuric fungicides again proved most effective in controlling brown-patch (*Rhizoctonia* spp.) of turf. The organic preparations (Uspulun, Semesan, Germisan, Corona—620, Corona—640) were effective against both the common types of disease. Adjacent plots were treated with mercuric chloride, sulphate, sulphide (black), oxide (red) and cyanide; mercurous chloride and nitrate; Uspulun; and Semesan. Each plot received an equal weight of metallic mercury. Results indicated that control was largely dependent on the amount of mercury present. Only the sulphide was ineffective. This probably was due to its insolubility in the soil acids. Injury to grass depends on the chemical combination, mercuric cyanide being most toxic and mercurous chloride least toxic. From the standpoint of control, toxicity, and cost, the most satisfactory chemical was mercurous chloride. Less than one-fifth pound of this compound proved fully as effective as one pound of Uspulun or Semesan, which cost approximately 10 times as much. Silver nitrate gave control similar to that of the mercury salts. Repeated applications of copper (copper sulphate, Bordeaux, copper stearate) resulted in an accumulation of copper which proved extremely toxic to the roots. Sulphur sprays or dusts likewise are injurious.

Formaldehyde, super-kalimat, phenol and sodium silicofluoride proved too toxic when used in amounts sufficient to control brown-patch.

The permeability of the seed coat of corn to mercury compounds. C. R. ORTON.

Permeability studies were conducted with four sweet and three dent varieties of corn using mercuric chloride (1: 1666), chlor-phenol-mercury sulphate (1: 400), nitro-phenol-mercury sulphate (1: 400) and cyan-cresol mercury (1: 400).

Uniform seeds were soaked in distilled water. Then the part of the seed coat covering the embryo and that covering the endosperm were removed and tested separately. They then were dried and cemented to the ground ends of glass tubing of uniform diameter and placed in sterile water for 24 hours. All leaking and imperfectly cemented seed coats were discarded.

The perfect seed coats were tested by placing two cubic centimeters of distilled water inside each tube. The tubes were then suspended in a mercuric solution of known concentration. Mercury in the distilled water inside the tube was detected by the sodium-hydrosulphite test.

Apparently that portion of the seed coat covering the embryo side of the seed is more slowly permeable than that covering the endosperm. It appears also that the rate of permeability of seed coats to each mercury compound varies with the corn varieties.

The four compounds naturally fall into three classes according to the approximate rate at which they pass through corn seed coats. Mercuric chloride and cyan-cresol-mercury pass through in approximately 30 minutes or less; nitro-phenol-mercury in an average of about 60 minutes; and chlor-phenol-mercury (Uspulun) requires an average of approximately 80 to 145 minutes.

Tree injection for control of fungous diseases and insect pests. C. M. SCHERER.

During the summer of 1926 American chestnut (*Castanea dentata*), white birch (*Betula alba*), gray birch (*Betula populifolia*), apple (*Malus* sp.), and American elm (*Ulmus americana*) were injected with various chemicals for the purpose of controlling chestnut blight (*Endothia parasitica*), bronze birch borer (*Agrilus anxius*), and European elm scale (*Gossyparia spuria*), respectively.

The chestnut trees were injected with acid fuchsin, acriflavine, aniline blue, basic fuchsin, Bayer Compound, brilliant green, ferrous sulphate, gentian violet, lithium carbonate, malachite green, methyl blue, safranin, Semesan, sodium carbonate, sodium fluoride, Sulfocide, thymol, zinc chloride, and Zonite; the birches with arsenic trioxide, Bayer Compound, Black-leaf 40, and strychnine sulphate; the apple with acid fuchsin, gentian violet, and thymol; and the elm with strychnine sulphate. These experiments included 85 chestnut, 75 birch, 22 apple, and 2 elm trees. The trees ranged from 1¼ inches to approximately 24 inches in diameter.

The smallest amount of any injected material was ½ gram of arsenic trioxide in a 1¼-inch birch, and the largest amount was 1,045 grams of strychnine sulphate in a 23-inch birch.

All results were negative with the exception of the apple trees which were injected with thymol. These seemed to show a definite resistance to the progress of *Bacillus amylovorus*.

Soil treatments for the control of damping-off in coniferous seed-beds. J. STEWART WIANT.

Experiments to determine the value of soil-treatments with certain chemicals for the control of damping-off in coniferous seed-beds, begun in 1925 at Ithaca, New York,

were continued in 1926 at Keene, New Hampshire. *Rhizoctonia solani* Kühn was the principal pathogene involved.

Effective control was secured in beds of *Pinus strobus* and *Picea excelsa* with chlorophenol-mercury (Semesan and Uspulun), mercuric chloride, and nitrophenol-mercury (Bayer Compound). In beds of *Pinus resinosa*, satisfactory results were obtained with aluminum sulphate—a fungicide recommended by Hartley and his associates, Uspulun, mercuric chloride, Bayer Compound, and sulphuric acid. The average damping-off in untreated beds of these three species was 43.5, 23, and 30.9 per cent, respectively. Under the conditions of these experriments, the above chemicals cannot be differentiated on the basis of their effectiveness as control agents.

Three organic mercury dusts furnished by the Bayer Company under the numbers 1–8, 101 and 112 gave significant increases over untreated beds in final stand of *Pinus resinosa* and to a somewhat lesser extent indicated value in beds of *P. sylvestris* and *Picea excelsa*. Copper carbonate, applied in powdered form at the rate of four to eight grams per square foot, produced severe chemical injury.

Sulphur and copper carbonate dusts as efficient fungicides for the control of sorghum kernel smut and millet smut. L. E. MELCHERS and C. O. JOHNSTON.

Fungicidal dust treatments will replace liquid methods for the control of kernel smut of sorghums and millet smut. Experimental results at the Kansas Agricultural Experiment Station have proved the effectiveness of copper carbonate for sorghum smut control. This treatment is widely prevalent in Kansas and is being introduced into other sorghum-growing states. Two years' results have proved the copper-carbonate treatment the most practicable and efficient method of millet-smut control. The same applications are used as for wheat smut, but the 50–55 per cent grades of copper carbonate are given preference.

Four seasons' results from extensive plantings of smutted sorghum seed treated with flowers of sulphur and the more reduced sulphur dusts, such as "Sulfodust" and "Kolodust," indicate a control of sorghum kernel smut equal to that obtained with copper carbonate. The cost of treatment is about one-sixth of one cent an acre. This includes labor, cost of sulphur and investment in equipment. The various sulphur dusts do not control millet smut satisfactorily. (Cooperative investigations by the Kansas Agricultural Experiment Station and the Office of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.)

The x-bodies in the cells of "mosaic diseased" and "dwarfed" dahlias. BESSIE GOLDSTEIN.

Intracellular bodies similar to the x-bodies of mosaiced tobacco, corn, *Hippeastrum*, and wheat have been found in the cells of dahlia plants affected with two types of disease—"mosaic" and "dwarf." They occur in all the tissues of young leaf primordia, growing points, and blotched leaves, though they are not present in yellow-margined leaves so far as studied. These intracellular bodies give very clear evidence that they are not mere reaction products of the cell protoplasm. They show a definite indication of flowing and elongation movements in the form of pseudopod-like extensions of the body surface. Structures resembling nuclei and vacuoles are present. They are found in all stages of what appears to be division by constriction, including such interesting forms as those in which the two divided halves of the body proper have become rounded up within a clear space, the stretched and constricting portion of what appears to be a membrane remaining still unbroken between them.

Cryptoporus volvatus and its relations with forest trees and insects. A. H. REGINALD BULLER.

Dendroctonus beetles and their allies, by means of their tunnels, prepare the way for the inoculation of coniferous trees with Cryptoporus spores and facilitate the production of Cryptoporus fruit-bodies on the exterior of the bark.

The fruit-bodies of *Cryptoporus volvatus* are unique among the Polyporeae in having their hymenial tubes contained in a chamber instead of being freely exposed to the air. The basal volva is perforated by an ostiole. Beetles and other insects enter the chamber and carry away spores which have settled on the volva. It is probable that certain of the spore-laden insects play an important rôle in the dissemination of the fungus. Some of the spores probably escape via the ostiole and are carried off by the wind. Fruit-bodies are sometimes formed at the mouths of entrance or exit tunnels of Ambrosia beetles, but there is no reason to suppose that these beetles cultivate *C. volvatus.*

Physiology and parasitism of Sclerotium rolfsii. B. B. HIGGINS.

The scope of the investigation includes: (1) temperature relations, (2) relation of reaction of the substratum to growth, (3) reaction changes in the substratum during growth, (4) metabolic products on various media, (5) relation of the metabolic products to parasitism, (6) relation of fungous hyphae to the host tissue.

The minimum, optimum, and maximum temperatures for growth are 8°, 30–35°, and 40° C., respectively. The maximum temperature for continued normal growth of the fungus appears to be about 37° C. Freezing kills the vegetative mycelium but the sclerotia withstand a temperature of – 10° C. for 48 hours.

The fungus grows on beef-extract-peptone broth from pH 1.4 to 8.3. Addition of 1 per cent NaCl to broth shortens both the alkaline and acid range. Addition of 2 per cent saccharose extends the alkaline range to pH 8.8 but shortens the acid range. The reaction of broth is changed by growth of the fungus toward a fairly definite end point near pH 4.0. In broth plus a carbohydrate there is no definite end point, but the change is always toward the acid side.

In beef-extract broth the principal products of growth are ammonia and oxalic acid with traces of succinic and formic acids. In broth plus a carbohydrate, less ammonia and more oxalic acid are produced. The amount of free oxalic acid is sufficient to kill the hypocotyl of tomato and soybean seedlings. The mycelium grows over the surface of a plant and kills the outer cells before entering the tissue. Oxalic acid may be readily demonstrated in the dead cells. Later the hyphae enter and produce a soft rot.

Serological differentiation of Bacterium campestre from Bact. phaseoli, Bact. phaseoli sojense, and Bact. flaccumfaciens. GEO. K. K. LINK and C. G. SHARP.

Bacterium campestre, Bact. phaseoli, Bact. flaccumfaciens and *Bact. phaseoli sojense* are yellow schizomycetes which in culture are quite similar morphologically and physiologically.

By serological methods it was attempted to determine whether *Bacterium campestre* (the crucifer pathogen) could be differentiated from the three yellow pathogens of beans, and to determine its relationship to them. Agglutination tests were applied to these organisms. Serum was prepared by injecting rabbits intravenously with live organisms, and bleeding them 10 days after the last injection.

In low dilutions, the writers obtained group agglutination with antisera of the bean organisms against *Bacterium campestre,* but did not obtain agglutination in any dilution with the anti-serum of *Bact. campestre* against *Bact. phaseoli, Bact. phaseoli sojense* and

Bact. flaccumfaciens. The anti-serum of *Bact. campestre* agglutinated *Bact. campestre* in dilution up to 1–7680.

On the basis of current interpretation, these results mean that *Bacterium campestre* contains no protein capable of stimulating production of an antibody which will react with *Bact. flaccumfaciens, Bact. phaseoli,* and *Bact. phaseoli sojense,* but that the bean pathogens contain proteins which cause production of antibodies that do react with *Bact. campestre.* Thus, *Bact. campestre* can be differentiated serologically from *Bact. phaseoli, Bact. phaseoli sojense* and *Bact. flaccumfaciens.* This means that these organisms, though closely related, are serologically distinct.

Serological and physiological studies of Bacterium phaseoli, Bact. phaseoli sojense, and Bact. flaccumfaciens. C. G. SHARP.

Agglutination tests have been applied to *Bacterium phaseoli, Bact. phaseoli sojense,* and *Bact. flaccumfaciens.* At first, serum was prepared by injecting rabbits interperitoneally with dead organisms and later intravenously with living ones. The rabbits were bled 10 days after the last injection. Later it was found that serum can be prepared by beginning injection intravenously with living organisms. Specific agglutination was obtained with each organism against its homologous serum in dilutions up to 320; no agglutination was obtained with heterologous sera. The results indicate that these organisms contain serologically different proteins, since they can be differentiated by agglutination tests.

Agglutination tests were supplemented by growing the organisms in 2 per cent sugar broths sterilized by filtration and adjusted to pH 6.8 to 7.2. In ten days, and longer, *Bacterium flaccumfaciens* formed sufficient acid in dextrose, galactose, levulose, lactose, and maltose to differentiate it from the other two organisms. In 30 days *Bact. phaseoli* and *Bact. phaseoli sojense* produced little change in dextrose, maltose and sucrose, but formed acid in galactose. In 30 days *Bact. phaseoli* changed levulose from pH 6.8 to pH 6.4–6.8 and lactose from pH 7.1 to pH 7.6. *Bact. phaseoli sojense* changed levulose to pH 7.3 and lactose to pH 8.2. The latter organism produces a characteristic surface growth and precipitate in lactose and levulose.

Formal titration of gelatin cultures of *Bact. phaseoli* and *Bact. phaseoli sojense* will not serve to differentiate between these organisms, but will differentiate *Bact. flaccumfaciens* from the others.

Pythium ultimum and Pythium debaryanum. CHARLES DRECHSLER.

Of the species of *Pythium* encountered in pathological relationships and assigned indiscriminately to *Pythium debaryanum* Hesse, the one most frequently concerned in damping-off, stem-rot, root-rot and rootlet injury is identical evidently with the forms discussed morphologically under this binomial by DeBary, Ward, and at least in part by Miyake. As pointed out by the writer in a note on *Pythium* infection of cabbage heads, it apparently never exhibits the condition figured by Hesse, *l.c.*, a longish antheridial branch arising from the hypha bearing the oogonium at a considerable distance from the latter. As the fungus is undoubtedly identical with *P. ultimum,* described by Trow as a saprophyte though presumably on inadequate evidence, it should be known by this binomial.

A fungus of which the usual relation between oogonium and antheridium approximates that represented in Hesse's figures is also frequently concerned in damping-off, root-rot and rootlet decay. Cylindrical-stalk antheridia and pouch-like antheridia arising in immediate proximity to the oogonium are decidedly rare. The oospore-wall is thinner than that of *Pythium ultimum* ($1.0 \pm \mu$ instead of $1.5 \pm \mu$), the "reserve glo-

bule'' larger, the strongly flattened refringent body oblate ellipsoidal rather than subspherical. Zoospores, never observed in *P. ultimum*, are here produced in moderate abundance. To this form, the oogonia and oospores of which do not differ greatly from those of *P. ultimum* in size (measuring respectively 22 ± μ and 18 ± μ in diameter in both species), the binomial *P. debaryanum* can more correctly be applied.

A peculiar type of Pythium. CHARLES DRECHSLER.

Three related species of peculiar pythiaceous fungi were isolated in 1926 from diseased stems and rootlets of various hosts including the bean, peony, ragweed and touch-me-not. The sporangia are terminal, often proliferous in moderate measure, and normally, as in *Pythium*, deliver their undifferentiated contents through an evacuation-tube of variable length into a vesicle where the zoospores are formed. Unlike Phytophthora, they do not discharge fully developed zoospores from a sessile papilla. In the sexual apparatus, features departing from the types more usually distinctive of *Pythium* are found in the elongated branch antheridium, roughly grub-like in shape, being closely applied to the oogonium along practically its entire length; in the fertilization-tube arising from a navel position on the antheridium; in the hyphal elements bearing the sexual organs exhibiting helicoid involvement regularly in one species, and more rarely in the other two; in the unusually thick-walled (3 ± μ) mature oospores containing approximately 15 to 20 vacuoles or ''reserve globules,'' and 5 to 10 smaller refringent bodies presumably to be interpreted as nuclei, instead of the single reserve globule and single refringent body present in the generality of forms usually assigned to the genus.

Relation of storage temperature to lag in growth of fungous cultures. D. H. ROSE and L. F. BUTLER.

When petri-dish cultures of *Physalospora rhodina* (Berk. & Curt.) Cooke and *Pleospora* sp. are withdrawn from the temperatures at which they have been held for six to eight days and placed at room temperature for two days longer, there is a lag in growth which is correlated with, and apparently due to, the temperatures at which they had previously been held. Cultures held at the four temperatures 3, 7, 11, and 13° C., with the variations in each case rarely more than ± 0.5° C., were studied. Immediately after removal from the temperature cabinets, the plates were spread in a single layer on a table and left two hours. Thermometer tests indicated that the plates all came to the room temperature within 80 minutes after being spread out. At the end of the two hours the plates were stacked and covered with cotton laboratory aprons. The results of the tests are given in table 1.

TABLE 1.—*Average increase in diameter of colonies upon removal from various storage temperatures to room temperature*

Name of fungus	No. of experiments	Hours exposure at room temperature	Av. increase in diameter of colonies (centimeters)			
			Previous temperatures			
			13° C.	11° C.	7° C.	3° C.
Physalospora	4	24	1.71	1.18	0.76	0.58
Pleospora	2	24	0.69	0.67	0.50	0.50
Physalospora	4	48	3.61	3.13	2.71	2.65
Pleospora	2	48	1.03	1.25	0.94	0.93

The effect of different hosts upon some species of Phytophthora. LEON H. LEONIAN.

The size and shape of Phytophthora sporangia constitute the most important characteristics in a strictly morphological classification. The followers of such a scheme must, of necessity, assume that the species is an immutable entity. The writer has shown that environmental conditions exert a tremendous influence upon the morphological features of *Phytophthora* spp. Since a host plant offers as many diverse physical and chemical factors as any laboratory medium or reagent, it is only natural to expect that different hosts exercise different influences upon the same species of fungus. With this point in view, the writer inoculated green tomatoes, green peppers, egg plants and potatoes with a number of *Phytophthora* spp. Ready infection and abundant fruiting followed. Sporangia from different hosts showed such striking dissimilarities in size and shape as to fool the most conservative morphologist.

The natural conclusion, therefore, is that a purely morphological system of classification is not of great value, and that only the more constant morphological features should be combined with reliable physiological reactions if a more satisfactory scheme of classification is desired.

Variation of strains of Alternaria solani isolated from lesions on potato tubers. REINER BONDE.

Alternaria solani cultures isolated from lesions on potato tubers were found to comprise distinct strains, which can be differentiated on the basis of formation of pigment in potato agar, rate of growth, macroscopic appearance of mycelium in culture, production of conidia, and pathogenicity on leaves and tubers. Saltations occur rather frequently in some strains, giving rise to new forms distinctly different from the parent. Some of the strains studied arose by saltation occurring *in vitro*. The strains cannot now be differentiated by measurements of the conidia.

The red pigment of the chromogenic strains was intensified by high temperatures and was retarded or absent at lower temperatures. Differences in acidity and alkalinity of the medium did not suppress pigmentation in the more chromogenic strains. Some intermediate strains were non-chromogenic in media of high acidity. Sunlight intensified the pigmentation of certain strains. Other strains remained non-chromogenic under all conditions of environment to which they were subjected. The pigment formed by *Alternaria solani* is deep red or carmine when alkaline, and yellow when acid.

The chromogenic character of the strains in media is not correlated with pathogenicity.

Clitocybe root-rot of trees and other woody plants in Florida. ARTHUR S. RHOADS.

During the past three years the writer has observed, at various points in Florida, several cases of mushroom root-rot of trees and other woody plants caused by *Clitocybe tabescens* (Scop.) Bres., which he previously reported as the cause of a root-rot of grapevines in Missouri (Jour. Agr. Res. 30: 341–364. 1924). Clitocybe root-rot has been observed most frequently in guava (*Psidium guajava*) trees, killing them in old citrus groves at Courtenay and Lotus on Merritts Island and at Cocoa, Rockledge, Bonaven ura, Mt. Dora, and Astor. Additional instances of equal severity have been observed in the case of eucalyptus trees at Cocoa, Okeechobee, Orlando, and Sebring; Australian pine (*Casuarina equisetifolia*) at Okeechobee and Rockledge; rose apple (*Caryophyllus jambos*) at Ft. Pierce, and poinsettia (*Euphorbia pulcherrima*) at Oakland.

Additional study may demonstrate that Clitocybe root-rot of various trees and other woody plants is of fairly widespread occurrence throughout Florida and other southern

states. Despite the frequently noted occurrence of Clitocybe root-rot in guava trees of long-established citrus groves, no instance has been found where citrus trees have been attacked.

A study of the downy mildew, Sclerospora graminicola (Sacc.) Schroet. I. E. MELHUS, FRANK VAN HALTERN, and D. E. BLISS.

A completely saturated atmosphere, turgid leaves covered with a film of moisture, and a temperature between 10° and 27° C. seem to favor sporulation of *Sclerospora graminicola* on *Setaria viridis* (L.) Beauv. Light apparently is not a factor. Under favorable conditions, sporulation occurs within 4 to 6 hours, and germination in water occurs in one hour at temperatures between 5° and 20° C. The optimum temperature is 14° to 18° C. The sporangia are forcibly discharged vertically 1.5 to 2.5 mm. and laterally 1.44 to 1.89 mm. *Sclerospora* has been reported on *Setaria glauca* several times, but it has never been collected by the authors, although the two species of *Setaria* regularly occur together in fields in Iowa and adjoining States.

Sclerospora hibernates by means of oospores rather than by intraseminal mycelium. The oospores require no rest period and, in dry conditions, remain viable at least 17 months. The minimum period of incubation following sporangial infection of corn by either oosporic or sporangial conidia is 6 days. Infection may take place near the base of the plumule 24 hours after the plumule emerges from the seed coat. Such infection generally is systemic. On corn, 11 per cent infection resulted from sporangia, and 91 per cent from oospores. The oospores were not killed after soaking 10 minutes in a 2 per cent copper-sulfate solution, nor when heated at 50° C. for one hour. Five minutes in one per cent formaldehyde inhibited oospore germination, while one-tenth per cent mercuric chloride for 40 minutes at room temperatures did not.

Some effects of mosaic on the content of the cell. MELVILLE T. COOK.

The cells of a series of leaves from the center to the outside from both mosaic and apparently healthy plants of sugar cane and tobacco have been studied for the purpose of determining the effects of mosaic. The chloroplasts in a mosaic plant are smaller and fewer than those in a healthy plant, but they tend to become normal with age. That is, the chloroplasts in the outside leaves of a mosaic plant are very nearly the same in appearance as those of a healthy plant. These studies indicate that the chloroplasts are not destroyed nor even injured by the disease. Their development, however, is inhibited. The nuclei of many mosaic cells are enlarged and otherwise deformed but they tend also to become normal with age. Islands of diseased cells are to be found in apparently healthy tissues, and islands of healthy cells in diseased tissues. There was no indication of recovery from the disease. Intracellular bodies were commonly found in diseased tobacco but rarely in diseased cane.

Separation of fern leaf from mottling in tomato mosaic. SOPHIA H. ECKERSON and H. R. KRAYBILL.

Juice from mosaic tomato plants was filtered through sintered glass filters having pores about 4 microns in diameter and through collodion membranes. By means of the glass filter it was possible to retain on the filter all of the infectious principle which produces mottling symptoms and to recover in the filtrate substances which produce fern-leaf and filiform symptoms in tomato plants similar to those frequently associated with tomato mosaic. If the tomato juice was allowed to stand in an ice box and then centrifuged, the juice when filtered through the glass filter would produce mottling symptoms. None

of the filtrates from collodion membranes produced typical mottling symptoms but some produced the fern-leaf and filiform symptoms. Attempts to infect other plants with the juice of plants showing only the fern-leaf symptoms were negative. Thus juice from the mosaic tomato plants was separated into two fractions, the residue containing the infectious principle (probably an organism) which produces typical tomato mosaic, and the filtrate, a non-infectious principle (possibly of the nature of toxins) which passes through collodion membranes and produces only fern-leaf and filiform symptoms with no mottling.

Multiplication of the virus of tobacco mosaic in detached leaves. HELEN A. PURDY.

The virus of tobacco mosaic, when inoculated into detached tobacco leaves, produces no macroscopic symptoms of disease but causes the production of intracellular bodies similar to those associated with tobacco mosaic in the leaves of growing plants. The appearance of these bodies after a definite incubation period and their occurrence in tissues distant from the point of inoculation indicates a development of the virus in the cells of the detached leaves.

Hoping to obtain further evidence of multiplication of the virus in cells of detached leaves, serial transmission experiments were undertaken. A known amount of virus was introduced into the first leaf of each series. After a period of incubation the sap was extracted from the leaf, diluted with distilled water and a given amount inoculated into a second detached leaf. In this manner, each leaf of a series was inoculated successively. The dilution of the original inoculum transferred was estimated in every case. The dilution used in the inoculation of the ninth leaf, juice from which produced mosaic in healthy plants, is estimated to be not less than 256×10^{18} in each series. This is many millions of times the water dilution necessary to inactivate the virus and indicates multiplication in the detached leaves.

Leafhopper injury to clover. E. A. HALLOWELL, JOHN MONTEITH, JR., and W. P. FLINT.

For several years an injury resembling tipburn or hopperburn of potatoes has been observed on clovers and other legumes. It was conspicuously prevalent and widespread during the summer of 1926, and was associated with an unusual abundance of leafhoppers. At Urbana, Illinois, red clover was grown in adjacent insect-proof cages, one heavily infected with leafhoppers (*Empoasca mali*), the other free from insects. These tests apparently demonstrated that leafhoppers were responsible for the condition observed, and further showed that the relatively glabrous English clover suffered more than the pubescent Tennessee strain. Affected leaves, sometimes simply yellowed or bronzed, are often slightly curled and usually show tip and marginal browning, while frequently the entire leaf turns brown. The plants remain dwarfed, and many die. As on potatoes, Bordeaux appeared to repel the leafhoppers, and the plants remained vigorous. On red clover at Arlington Farm, Virginia, where numerous species of leafhoppers were abundant, the damage was most noticeable on Italian clover, while the native hairy strains showed much less injury. Zigzag, alsike, and white clovers showed similar symptoms in varying degree. Alfalfa in Italian clover plots, as well as in extensive plantings nearby, was likewise severely dwarfed and had the typical "yellows" or "yellow-top" appearance.

Investigations on citrus "blight," wilt or leaf-curl in Florida. ARTHUR S. RHOADS.

During the past three years, an intensive study has been made of a chronic wilt of citrus trees, locally called "blight," or leaf-curl, that has caused heavy losses in groves of certain sections of Florida during the past 40 years. Extensive experiments in bud-

ding young trees and grafting older ones demonstrated that this trouble is not transmissible. No evidence was obtained to indicate that a pathogenic organism is responsible for this trouble. It is believed to be of non-parasitic origin, and traceable to extremes in soil-moisture conditions. There is a well-defined relation between the occurrence of citrus "blight" and the water-holding capacity of the soil type. This trouble appears to be caused most frequently by an inadequate supply of soil moisture during the dry season of the year. Often it may be due also to excessive amounts of soil moisture resulting from prolonged saturation of poorly drained grove areas. Again, it may be intensified by the recurrence of drouth following an excessively wet season. Citrus "blight" clearly is greatly favored by neglectful care of the grove. After the trees develop the chronic wilt, control appears possible only through adoption of preventive rather than remedial measures.

A serious disease of birches. PERLEY SPAULDING.

There has appeared within a few years a serious disease of various birches in our eastern forests. In 1919 A. H. Graves published concerning a Nectria canker of *Betula lenta* L. and still earlier Pollock mentioned a Nectria canker of *B. lutea* Michx. During the summer of 1926 a similar disease was found apparently epidemic on *B. lutea* in Vermont and on *B. lenta* in Massachusetts. There is much diversity in the symptoms, but after studying them for some days the writer came to the conclusion that he also was dealing with a disease caused by *Nectria*. Foresters have been alarmed during the last few years by an increasing decrepit condition of yellow birch and have attributed it to the bronze birch borer. The trouble found by the writer seems not to be due to an insect though the borer is not excluded as a cause of serious injury. Cultures are being made for further work. While the disease is not generally serious, it may be well to have it in mind so that its range, virulence and economic importance can be learned. Any notes concerning it will be much appreciated.